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July 2015

STRESS TESTING—TECHNICAL NOTE

This Technical Note on Stress Testing on the United States was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed in June 2015.

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Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared in the context of an IMF Financial Sector Assessment Program (FSAP) mission to the United States of America, led by Aditya Narain and overseen by the Monetary and Capital Markets Department, IMF. Further information on the FSAP program can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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APPENDICES

Glossary

AFS	Available for Sale
AOCI	Accumulated Other Comprehensive Income
APT	Asset Pricing Theory
BCBS	Basel Committee on Banking Supervision
BHC	Bank Holding Company
BU	Bottom-up
CET1	Common Equity Tier 1
CCA	Contingent Claims Analysis
CCB	Conservation Capital Buffer
CRSP	Center for Research in Security Prices
DFA	Dodd-Frank Act
DFAST	Dodd-Frank Act Stress Test
CDS	Credit Default Swaps
DFAST	Dodd-Frank Act Stress Test
FDIC	Federal Deposit Insurance Corporation
FSB	Financial Stability Board
FRB	Federal Reserve Board
GAMLSS	General Adaptive Models of Location, Scale, and Shape
GAIC	Generalized Akaike Information Criteria
GSIBs	Globally Systemically Important Banks
GSIIs	Globally Systemically Important Insurers
HTM	Hold to Maturity
LCR	Liquidity Coverage Ratio
MBSs	Mortgage-Backed Securities
MCSR	Marginal Contribution to Systemic Risk
NAIC	National Association of Insurance Commissioners
NBFI	Nonbank Financial Institution
NSFR	Net Stable Funding Ratio
OCC	Office of Comptroller of the Currency
OTC	Over-the-Counter
PELT	Pruned Exact Linear Time
P&C	Property & Casualty Insurance
PD	Probability of Default
RBC	Risk-Based Capital
RWAs	Risk Weighted Assets
SRISK	Systemic Risk Measure
SyRIN	Systemic Risk Indicators
TAC	Total Adjusted Capital
VaR	Value at Risk
WEO	World Economic Outlook

EXECUTIVE SUMMARY[1]

1. A range of stress tests was used to quantify the potential impacts of risks and vulnerabilities in bank and nonbank sectors. The stress testing exercise reflected a broader evaluation of potential risks, embodied in the Risk Assessment Matrix (Appendix I). To provide a more comprehensive assessment than possible with any single approach, the stress testing exercise comprised several approaches. The FSAP team conducted top-down solvency tests for bank holding companies (BHCs) and insurance companies, liquidity risk analysis for BHCs and mutual funds, as well as market-price based stress tests. Moreover, the exercise was informed by the supervisory (top-down) stress tests performed by the U.S. authorities for the banking sector and the insurance sector, and by company-run (bottom-up) stress tests performed by BHCs. The exercise thus covered both banks and nonbanks (including insurance companies and mutual funds). It encompassed solvency and liquidity risks, as well as contagion risks. In the case of BHCs, the tests performed by IMF staff complement the Dodd-Frank Act stress test (DFAST) results.

2. The stress tests run by the authorities and by companies under the DFA suggest that most large BHCs are resilient to shocks similar to the last crisis. The DFA requires the FRB to conduct an annual supervisory stress test of BHCs with total consolidated assets of $50 billion or more. It also requires all financial institutions with total consolidated assets of more than $10 billion to conduct company-run stress tests at least once a year. The results of the 2015 supervisory and company run stress tests, released in March, suggest that the system is resilient to severe shocks. Even in the severely adverse scenario (resembling the 2008–09 crisis), all the 31 BHCs have sufficient capital to absorb losses, which is the first time since the start of annual stress tests in 2009 that no firm fell below any of the main capital thresholds. The tests do not cover insurance and other nonbank financial institutions and do not capture network effects or analyze liquidity risks.

3. The staff's analysis benefitted from the relatively wide range of publicly available data, but was nonetheless subject to data constraints. Due to constraints on the authorities' ability to share confidential supervisory information with the team, the analysis relied largely on publicly available data. The public data gathered was very extensive, but had notable gaps in some areas. For example, a lack of security-level granularity in publicly available data made full-fledged liquidity stress testing for BHCs and mutual funds a challenge. Data on interconnectedness among financial institutions have important gaps, although the authorities assisted the team in performing a contagion stress test for a sample of large BHCs. The insurance sector analysis was also constrained

[1] The work on the note, prepared as part of the 2015 U.S. FSAP, was coordinated by Martin Čihák and carried out between October 2014 and March 2015.The main authors are Ivo Krznar (bank holding company stress tests, mutual funds stress test), Timo Broszeit (insurance stress tests), Dale Gray (market-based analysis), Ben Huston (market-based analysis and support on bank holding company and mutual fund stress tests), and Juan Solé (network analysis). Important contributions were provided by Miguel Segoviano, Jay Surti, Nobuyasu Sugimoto, Sheheryar Malik, Naixi Wang, Deniz Igan, and Fabian Lipinsky. The note reflects comments and suggestions from other IMF colleagues. The FSAP team would like to express its gratitude to counterparts at the Federal Reserve Board (FRB), the U.S. Treasury, OCC, FDIC, SEC, NAIC, FIO, and other federal and state officials for all discussions and comments. The work has also benefitted from interactions with private sector participants and analysts.

by valuation practices in the United States, complexity of the insurance business and its regulation, and the absence of group-level risk-based capital.

4. The solvency stress test considered two scenarios—baseline and stress—and a range of sensitivity checks. The baseline scenario was informed by the Blue Chip Economic Consensus and broadly reflected the IMF's *World Economic Outlook* (WEO) projections as of January 2015. The stress scenario was based on the severely adverse scenario from the DFAST, which was deemed appropriately stressful from the FSAP viewpoint. The scenario horizon was expanded to 5 years to bring it closer in line with recent FSAPs. The trajectories and co-movements of key variables were informed by post-war U.S. recessions, with scenario severity calibrated to be similar to the 2007–09 recession. In the scenario, the unemployment rate rose by 4 percentage points over a two-year period. Real GDP was 4.5 percent lower than the baseline by the end of 2015 (GDP growth rates were negative for 5 quarters), equity prices fell by 60 percent in one year, house prices declined by 25 percent over the first two years, corporate spreads rose by 330 basis points, and mortgage rates increased by 80 basis points.

5. For BHCs, the staff's solvency stress tests over the initial stressed period are largely in line with the DFAST results, and suggest that the system is generally robust, although some BHCs would fall below the hurdle rate in the stressed environment.

- Banking stress tests covered the largest 31 BHCs—the same as under the DFAST—constituting 85 percent of sectoral assets. The institutions were subjected to credit and liquidity risks in the context of a stress scenario. All tests were conducted based on publicly available, consolidated data as of September 2014. The solvency stress tests assessed the level of banks' Basel III Common Equity Tier 1 ratios against a hurdle rate consisting of the regulatory minimum consistent with the Basel III transition schedule augmented by the capital conservation buffer and a capital surcharge for Globally Systemically Important Banks (GSIBs) which are both phased in over the forecast period. The hurdle rates in the IMF stress test were more stringent than in the DFAST where the hurdle rate was consistent with the Basel III transition schedule.

- The system-wide CET 1 ratio would fall by 2½ percentage points in 2015 (or 2¼ percentage points relative to the baseline scenario) and no BHCs would fall below the hurdle rate in the first year, reflecting BHCs' already high capital positions.

- However, capital ratios do fall below the hurdle rate in subsequent years. Two BHCs fall below the hurdle rate in 2016 and an additional eleven BHCs do so during the recovery period. Recapitalization needs peak in 2019 at 180 percent of 2014 net income (corresponding to 1 percent of 2019 nominal GDP). While effects on capital ratios in the period of negative economic growth were largely driven by credit and trading losses, changes in capital ratios during the recovery period (2017–19) were mainly due to assumed increases in risk weighted assets, a higher hurdle rate due to phase-in of Basel III deductions, sluggish interest income growth, and higher dividend distributions. Although the results are conservative, since the BHCs would not likely increase their balance sheets if this were to

take them below the regulatory threshold, this does illustrate that some BHCs could face difficulties in supporting credit growth in the event of a large shock.

6. Staff's liquidity risk analysis suggests that most BHCs have enough liquid assets to meet a liquidity shock similar to the 2008/2009 event. A few BHCs would face liquidity pressures due to deposit outflows in the short run and large unused commitments over a longer stress horizon. If faced with a much larger shock, as characterized by an approximation of the LCR run-off rates, liquid assets for many BHCs would not be sufficient to meet liquidity needs due to large withdrawal of wholesale funding.

7. On the insurance side, stresses have a significant impact, especially in life insurance. The top-down group-level stress test for 43 insurance groups has limitations due to incomplete data, valuation practices in the United States, the complexity of the insurance business, and the absence of group-level risk-based capital. With these caveats, the team's top-down stress tests suggest that market stresses would cause substantial reduction of shareholder equity of life insurers if a "fully market-consistent" valuation was applied; non-life insurers would be less affected. An equivalent of the "severely adverse" scenario would lead to at least 17 distressed companies (16 life insurers and 1 credit insurer). Shareholder equity of these groups would turn negative if the materialization of market risk shocks occurred instantaneously, thereby effectively reducing the full coverage of insurance liabilities with eligible assets. The current valuation regime, however, would not recognize the impact of these asset shocks except over time, as impairments are only required when losses are significant or prolonged. An additional exercise based on statutory accounting shows the sector in a more robust shape, as mark-to-market losses would only partially be reflected in the balance sheet. The results of this exercise are broadly in line with the top-down stress test performed by the NAIC.

8. Calculations for managed funds underscore the liquidity risk in the asset management industry. The increased investment by open-ended mutual funds in relatively less liquid assets leaves them more susceptible to runs and suggests that their response to redemption pressures could exacerbate market stress. This risk was assessed by analysis geared to measuring whether markets would be able to absorb severe redemption pressures wherein these funds are forced to liquidate positions. Specifically, a top-down liquidity analysis was performed, covering some 9,000 mutual funds representing around 80 percent of the industry. Assets sold by mutual funds hit by a stress shock were compared to data on dealers' inventory. The stress shock was defined as a one time, tail event (1 percent) redemption shock. The results of the stress test suggest that mutual funds that invest in municipal bonds and corporate bonds might face liquidity problems. While subject to important data limitations, the tests illustrate the danger that these funds might sell their assets at a fire-sale discount to meet redemptions. More work is needed on the quality of underlying data. The authorities are encouraged to perform liquidity risk analysis for the mutual fund industry on a regular basis and further strengthen guidance to the industry in this regard.

9. A network stress-test methodology was used to assess potential spillovers among the largest domestic GSIBs. The methodology consists of simulating credit and funding shocks within a

network of institutions and tracking the contagion effects in terms of capital losses and path of bank failures. The methodology also allows for the assessment of the systemic impact arising from existing off-balance sheet financial linkages (e.g., credit default swaps). Due to data limitations, the exercise focused only on six largest U.S. GSIBs, accounting for 52 percent of BHCs' total assets. The results indicate that the six largest BHCs hold enough capital to sustain a range of credit and funding shocks to individual counterparties within the network, and contagion risk appears contained. This is likely because direct exposures within the six-bank holding company network are not large enough relative to the initial capital of each institution to lead to second-round spillovers. Nonetheless, the calculations also suggest that risk transfer instruments, such as credit default swaps, alter dramatically the risk profile of financial institutions. The results thus illustrate the importance of monitoring and stress-testing off-balance sheet exposures, The results are also suggestive of the need to expand the data on exposures included in the network (e.g., exposure of the BHCs to money market funds), as well as consider richer market dynamics in the simulations (e.g., downward spirals in the value of certain financial assets).

10. Nonbank financial institutions and markets account for a majority of systemic risk. The quantitative analysis of systemic risk suggests that marginal contributions to systemic risk outside of the banking system have increased. Banks are sizable, accounting for some 30 percent of assets, and their contribution to systemic risk remains large. Nonetheless, the staff's analysis of interconnectedness of the different segments of the system illustrates that the systemic risks posed by bond funds, money market funds, separate funds and equity managers may be small in absolute terms, but they are large in relation to their size, reflecting their interconnectedness with banks and other financial sector components.

11. Market-price based stress tests were used to illustrate the importance of cross-sectoral spillovers under stress. Market-price based analysis has important limitations that reflect the underlying modeling assumptions as well as the quality of the underlying market data. But given the relatively high level of development, high liquidity, transparency, and sophistication of U.S. financial markets, market-based models provide useful complementary information. The results suggested:

- The system as a whole appears less vulnerable to large adverse macroeconomic shocks than during the recent crisis, but default probabilities would still rise to levels that would suggest significant systemic stress.

- Cross-sector spillovers amplify the effects of shocks. U.S. banks, insurers, and other non-bank financial institutions tend to be adversely affected by credit risk shocks originating in other domestic sectors. And while spillovers from insurance companies to banks are small, when macroeconomic conditions are held constant, they are large otherwise. This suggests that the risks that insurers pose to the system stems from their own vulnerability to macroeconomic shocks.

- Spillovers from the United States to the rest of the world can be large. This is particularly true for the foreign banking sector, while the foreign insurance sector is most negatively

affected by adverse changes in the credit profile of U.S. asset managers and insurers. Spillbacks from the rest of the world appear to be relatively modest.

12. While the authorities' stress testing is state-of-the art in many respects, the exercise has suggested some scope for enhancements (Table 1). These include addressing data gaps by collecting interbank exposures for the whole sample of BHCs that were stress tested and conducting a network analysis on a regular basis; establishing a liquidity stress testing framework; trying to link liquidity, solvency and network analysis in a systemic risk stress testing framework; reexamining some of the solvency stress test assumptions to make them consistent with historical evidence, for example, as part of sensitivity analyses; as well as performing regular liquidity stress tests for open ended mutual funds and further strengthening the guidance to the industry on liquidity risk analysis.

Table 1. Stress Testing Recommendations

General
• Conduct regular, comprehensive stress tests for all major financial sub-sectors that capture the impact of macro-financial factors, spillover and feedback effects between institutions and interactions between solvency and liquidity. • Conduct more intensive monitoring of systemic financial sector risks, including the use of market-based solvency and shortfall measures.
Banking
• Conduct liquidity stress testing on a regular basis. • Collect consistent interbank exposure data, and run network analysis on a regular basis. • Link liquidity, solvency and network analyses in a systemic risk stress testing framework. • Reexamine DFAST solvency stress test assumptions (e.g., regarding loan and balance sheet growth and dividend distribution) to confirm that they are consistent with historical evidence.
Insurance
• Develop and perform insurance stress tests on a consolidated, group-level basis, especially for groups that are (i) designated as systemically important; (ii) engaged in material group-internal risk transfer, e.g. via captives; or (iii) exposed to non-linear market risks through the sale of products which include guarantees or optionalities, e.g. variable annuities. • Improve public disclosure by requiring insurance companies to disclose market risk sensitivities in a more harmonized manner.
Mutual Funds
• Develop and perform liquidity risk analysis for the mutual fund industry on a regular basis; further strengthen guidance to the industry on liquidity risk analysis.

INTRODUCTION

13. This note provides the methodology and results of stress tests of the financial sector carried out in the 2015 FSAP assessment for the United States. To obtain a more comprehensive assessment than possible with any single approach, the U.S. FSAP stress tests combined three groups of complementary approaches. The first group consisted of the IMF's top-down stress tests for BHCs, insurance companies, and mutual funds. The second group included the Fed's top-down (supervisory DFAST) tests for BHCs and bottom-up stress tests run by the companies (company run DFAST). The third group included a broad range of IMF's top-down calculations using market-price data (Table 2 and Appendix I). The findings of the stress tests were used to provide quantitative support for the FSAP's stability risk assessment by estimating the impact from the realization of key tail risks and to facilitate policy discussions on risk mitigation strategies and crisis preparedness.

Table 2. Stress Testing: Overview of the Exercises Done by the IMF

Exercise type	Coverage	Scenarios	Cut-off date; data frequency; stress test horizon
IMF top down (solvency) test	31 Bank Holding Companies plus additional 2 BHCs and 2 savings banks in the sensitivity analysis (6 systemic BHCs for network stress testing)	Scenarios taken from DFAST, extended using WEO; sensitivity analysis and network analysis	2014Q3; quarterly; 5 year stress test horizon
Bank liquidity risk analysis	31 Bank Holding Companies	Range of adverse scenarios	2014Q3; quarterly; instantaneous shock
Insurance stress testing	43 insurance groups (20 life, 16 property & casualty, 5 health insurance, and 2 credit and mortgage insurance).	Scenarios taken from DFAST	End-2014 data
Mutual fund liquidity risk analysis	9,000 mutual funds (80 percent of the industry)	Range of adverse scenarios	2014Q3; quarterly, instantaneous shock
Market-price based network analysis and stress testing	210 institutions (U.S. banks, insurers, NBFIs, asset managers, nonfinancial firms; foreign banks and insurers)	Scenarios taken from DFAST, extended using WEO	2014Q3; daily

Note: for details, see the Stress Test Matrix (Appendix Table 2). Table 2 focuses on IMF-run stress tests and does not include the supervisory and companies-run stress tests that informed this exercise.

IMF STAFF'S SOLVENCY STRESS TESTS FOR BANK HOLDING COMPANIES

14. This section explains the top-down solvency stress tests of the IMF FSAP team. The section covers: (i) overview of scope, (ii) the state of the banking sector; (iii) the macroeconomic scenarios; (iv) the capital definitions and standards that were used for calculating and reporting results; (v) the stress test methodology and the use of models to map the macroeconomic scenarios into credit losses, income projections, balance sheet items and risk weighted assets; (vi) the behavioral assumptions governing capital actions in the stress test scenarios, (v) the network analysis performed and (vii) the results of the stress test.

A. Scope of the Test

15. The top-down test followed the balance sheet-based approach. This assesses solvency of individual BHCs under the baseline and stress scenarios through changes in net income and risk-weighted assets. A range of sensitivity analysis was performed to supplement the two scenarios. This approach was comparable to the company run DFAST (bottom-up) and supervisory DFAST (top-down), despite some important differences (Table 12). It can be seen as complementary to the DFAST exercise.

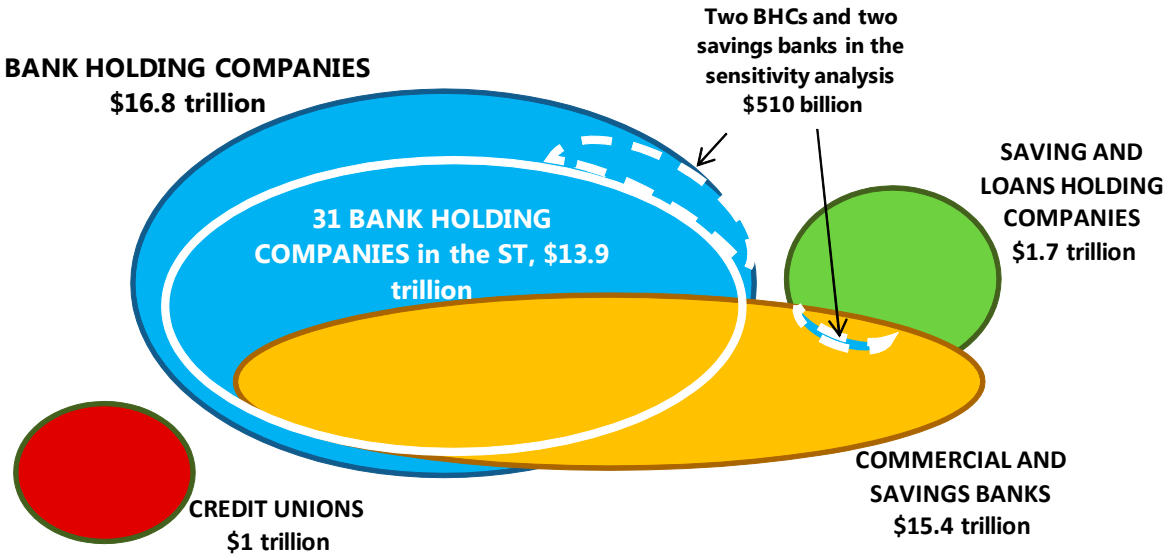
16. The stress test used publicly available, consolidated data. These cover individual BHCs from regulatory reports (FR Y-9C) provided by SNL Financial that take into account structural breaks resulting from bank mergers and acquisitions.

17. The coverage of the IMF top-down test was the same as in the DFAST, which increased the comparability of results. Results of the test were calculated by individual institution. The stress test covered 31 largest BHCs (with total consolidated assets of $50 billion and more), which account for about 85 percent of the BHC assets and 70 percent of total banking sector assets, defined as total assets of BHCs, savings and loans holding companies (SLHC) and commercial and savings banks that are not part of any BHC or SLHC (Figure 1). The network analysis was based on six largest BHCs, accounting for 52 percent of total BHC assets.

18. While the test's coverage in terms of total banking sector assets is comparable with other FSAPs, some large depository institutions were not included. BHCs with assets of $10 billion and more but less than $50 billion (which represent around 5 percent of the BHC assets) were not included. Most banking organizations (commercial banks and saving institutions) with assets of $50 billion and more that are regulated by OCC and the FDIC and are subject to bottom-up tests (company-run DFAST), were implicitly included in the top-down stress test, as they are subsidiaries of BHCs included in the top-down stress test. The exceptions are two banks (one regulated by the FDIC and the other by OCC) that are part of BHCs that will be subject to supervisory DFAST in the future

and two banks that are part of large SLHCs (regulated by OCC)[2]. These institutions were stress tested as part of a robustness check (Figure 1). Moreover, one depository institution—the largest credit union—has assets exceeding $50 billion but was not included in the stress test, because it was not subject to risk-based capital requirements used by other federal banking regulatory agencies as of 2014Q3.[3] Large SLHCs were not included in any stress test as they were not subject to capital requirements as of 2014Q3.[4] SLHCs with assets of $50 billion and more represent 10 percent of total holding companies' assets with assets of $50 billion and more. They will be required to perform DFA company-run stress tests in the future.

Figure 1. Structure of the U.S. Banking Sector



Source: Federal Reserve Board, IMF Staff calculations.

19. The cut-off date for the data was September 30, 2014. Minimum capital requirements used as hurdle rates were consistent with the revised capital regulatory standards that reflect Basel III capital standards including both the capital conservation buffer and a GSIB capital surcharge (calculated using the BCBS framework), on a phased-in basis, as minimums. The hurdle rates in the

[2] There are also large U.S. branches of a foreign institution that could not be included in the solvency test as they do not hold any capital.

[3] National Credit Union Administration, the regulator of all federal credit unions, issued (in January 2015) for comments a proposed rule that would amend the agency's current risk-based net worth requirement by replacing the current risk-based net worth ratio with a new risk-based capital ratio for federally insured natural person credit unions. The new capital requirements would be more consistent with regulatory risk-based capital measures used by the FDIC, OCC and Board of Governors of the Federal Reserve.

[4] Their capital requirement schedule (Schedule HC-R) of the FR Y-9C was empty. Therefore, the calculation of their CET1 capital and their risk weighted assets was not possible.

IMF stress test were more stringent than in the DFAST's, which were consistent with the Basel III transition schedule and did not include capital conservation buffer or a GSIB capital surcharge.

B. Bank Holding Companies: An Overview

20. This section provides an overview of BHCs included in the stress tests (Appendix Figure 1). It analyzes the structure of balance sheets and income statements as well as off-balance sheet items. Moreover, it provides some detailed information on GSIBs.

21. Assets of 31 largest BHCs rose by 11 percent since the last FSAP and 18 percent since the crisis. Total assets of the largest BHCs represent 80 percent of nominal GDP. The increase in assets was primarily driven by increases in cash, federal funds bought and reverse repos and available-for-sales securities portfolio. Much of this growth reflects impacts of Quantitative Easing policies on bank balance sheets—impacts that are likely to be at least partially reversed with the upcoming unwind. Cash now accounts for 12 percent of total asset compared to 3 percent before the crisis. The increase in federal funds and repo mostly reflect a large increase in 2009. Securities holding have expanded by 60 percent since 2008 due to increases in holdings of available for sale (AFS) securities—as holdings of mortgage-backed securities (MBSs), Treasury securities and foreign debt securities increased—which increases BHCs exposure to interest rate risk.[5] Half of the AFS portfolio pertains to MBSs, followed by Treasury securities (16 percent) and foreign debt securities (14 percent). As of 2014Q3 trading assets are lower by about 10 percent comparing to 2008 which is partly due to the implementation of the Volcker rule which severely restricts proprietary trading.

22. Total net loans are the largest asset category accounting for 40 percent of total assets, slightly lower than in 2008 or before the crisis. While total loans have increased by 10 percent the structure of loans has changed since the crisis. Real estate loans, the largest loan type, account for 28 percent of total loans, down from 36 percent in 2008. This was mainly due to lower revolving, open end real estate loans extended under lines of credit and close-end junior lien real estate loans as underwriting standards for those loans tightened considerably mostly by requiring more documentation and by imposing debt service ratio (OCC, 2014). On the other hand, loans to financial institutions increased their share to about 10 percent driven by increases in loans to non-depository financial institutions and loans for purchasing securities. Rapid loan growth since the beginning of 2013 driven by business loans calls for continued vigilance given evidence of weakening underwriting, especially in the leveraged loans market.[6]

23. Deposit growth, which accounted for the bulk of funding growth, supported the growth of assets. Deposits are 40 percent larger than in 2008 and account for 53 percent of total liabilities and 132 percent of loans. The deposit-to-loan ratio is 21 percentage points higher than in

[5] Moreover, at largest banks asset maturities have been stable but liability maturities have gotten shorter (Bednar and Elamin, 2014). Small banks are particularly exposed to interest rate risk as their asset maturities have gotten longer and liability maturities have gotten shorter.

[6] Leveraged loan issuance in 2015 has started to decrease following intra-agency leveraged lending guidance.

2010 and 30 percentage points higher than before the crisis partly due to record corporate cash holdings. About 60 percent of deposits are money market deposits. Stable deposits[7] account for almost 90 percent of total deposits and less stable deposits have significantly decreased since the crisis due to lower large, short-term domestic and foreign time deposits.

24. Deposit growth, along with deleveraging, has reduced BHCs' reliance on wholesale funding. Non-deposit liabilities such as repos, trading liabilities and other wholesale funding are 10 percent lower than in 2009. Wholesale funding (defined as repos, trading liabilities, subordinated notes and brokered deposits) account for 30 percent of total liabilities. The bulk of wholesale funding pertains to other borrowed money (50 percent) and repos (25 percent). The maturity of other borrowed money has been extended since 2008 and most of other borrowed money (70 percent) in 2014 is related to unsecured liabilities and liabilities with maturity of 1 year and more.

25. Total equity has increased by 70 percent driven by retained earnings and surpluses, which have doubled since the crisis, largely in response to the higher regulatory requirements. CET 1 capital ratio has doubled since the crisis to 12 percent at the end of 2014Q3. The leverage ratio (defined as CET1 over total assets) has more than doubled to 8 percent since the end of 2008.

26. Off balance sheet activity has fallen since 2009 mostly due to lower holdings of derivatives, notwithstanding an increase in unused commitments. While the derivatives (credit equivalent) have fallen by 30 percent, unused commitments have increased by 5 percent since the crisis and still represent the largest off balance sheet item. The largest share of unused commitments pertains to consumer credit card lines (40 percent) and commercial and industrial loans (25 percent). The structure of unused commitments has changed since the crisis. Although unused credit card lines have fallen, unused commitments on commercial and industrial loans and loans to financial institutions have increased by 30 percent. Securities lending is the second largest off balance sheet item with a share of around 20 percent of total off balance sheet activity. Interest rate contracts are the largest component of derivatives portfolio (82 percent) followed by foreign exchange contracts (14 percent). Credit derivatives have been cut in half since 2009 and represent a small proportion of derivatives activities where most contracts are related to purchased or sold investment grade credit default swaps. Swaps and forward contracts dominate the derivative contracts. Almost the whole derivative portfolio is held for trading. In most of OTC derivatives transactions cash is the main collateral and major counterparties are banks and securities firms and non-financial corporate firms.

27. While BHCs have made material improvements in nonperforming loans, underwriting standards have continued to loosen since 2011 (Appendix Figure 2). Economic recovery has been conducive to further strengthening of the BHCs' balance sheets. Delinquent and non-performing loans have continued to fall since their peak in 2009. Delinquency rates and NPLs have been cut in half since end 2009 and now stand at 3.5 and 2.5 percent respectively. Most of bad loans consist of

[7] Stable deposits are defined as total deposits minus brokered deposits minus large deposits and foreign deposits maturing within a year.

residential mortgage loans. Non-real estate mortgage delinquent loans are at the levels before the crisis. Net charge-off rates are considerably lower than in 2009 but still higher than before the crisis due to higher charge-offs for consumer loans. However, regulatory surveys from the OCC suggest looser underwriting in commercial real estate, commercial and industrial loans, and auto loans with some banks having significant exposure to subprime auto loans. Moreover, LTVs for CRE loans are approaching their pre-crisis levels suggesting continuing monitoring is needed. The largest BHCs seem resilient to the recent oil price drop since their direct loan exposure to energy-related companies is only in the range of 1.2 to 5 percent their total loans.

28. While the BHCs have posted all time high profits in 2014Q3, there is a large dispersion of profitability indicators across BHCs. Net income has increased substantially since the last FSAP driven by lower provisions which have come down to pre-crisis levels and higher non-interest income. Net interest margins continue to compress as a result of protracted low interest rates, banks' increased holding of liquid assets because of regulatory requirements as well as heightened loan competition. Non-interest expenses are 35 percent higher in 2014Q3 than in 2008, partly due to litigation-related charges and cyber security protection. Return on equity (ROE) is about 50 percent smaller than before the crisis mainly due to higher capitalization of BHCs. Return on assets are 20 bps lower than before the crisis. While profitability of all BHCs is relatively high there are large differences across BHCs, which, for some large BHCs, is also due to litigation charges stemming from BHCs' business practices leading up to the crisis.[8] Many BHCs are seeking to enhance their ROE by looking for new business, principally through new loan growth or reconfiguration of business models which increases the risk of relaxation of underwriting standards.

29. There are large differences in business models across BHCs. BHCs can be differentiated based on the largest asset category. Most of the BHCs are focused on lending as the main business activity. The second type of BHCs is more involved in capital market activities. The largest asset item of the third type of BHCs pertains to AFS securities. In general, BHCs with high proportion of loans have lower leverage, lower off balance sheet activities and are less involved in wholesale activities such as reverse repo and trading. They use deposits as a major source of funding and are more profitable than other types of BHCs. On the other hand, BHCs that have large trading activities are less involved in lending but more involved in reverse repo transactions. They are funded more on the wholesale market and have higher leverage. They also have higher NPLs, which might imply that they can't compete with BHCs whose lending represents their core business or that they are less constrained by regulatory capital ratios and are searching for yield by targeting riskier loans. The third type of BHCs, of which the largest three BHCs have large operations as custodian banks, is less involved in lending, trading and repo transactions. They have higher leverage and off balance sheet activities but at the same time large deposit base.

30. Total assets of GSIBs have reached about $10 trillion and represent 75 percent of total assets of all BHCs included in the stress test (Appendix Figure 3). When derivatives positions and

[8] The large BHCs continue to be plagued by very elevated litigation-related charges.

securities financing transactions are added their total exposure is about 35 percent higher than their total assets. Around 25 percent of their assets are related to foreign exposures and on average, they derive about ¼ of their total net revenue from foreign business. The largest component of foreign loans pertain to commercial and industrial loans. Securitization, mostly of mortgage loans, represents 11 percent of GSIBs assets but with large differences across BHCs. Securities (trading and AFS) account for 30 percent of their total assets. The structure of investment and AFS securities portfolios is very similar- MBSs (45 percent) and Treasury securities (around 20 percent) represent almost 2/3 of portfolios.

31. GSIBs are interconnected with the rest of the financial system. Intra-financial system assets represent 22 percent of GSIBs' assets while intra-financial system liabilities represent 16 percent of their total liabilities with notable differences across GSIBs. The largest component of inta-financial system assets is the fair value and potential future exposure of OTC derivatives (52 percent), followed by deposits (20 percent). Most of the intra-financial liabilities pertain to deposits (47 percent; most of deposits were due to non-bank financial institutions) and OTC derivatives (35 percent). Almost half of OTC derivatives are cleared through a central counterparty.

C. Macroeconomic Scenarios

32. The solvency stress tests examined two macroeconomic scenarios: a baseline and a stress scenario over a five year horizon (Box 1, Appendix Figure 4). These scenarios were developed by the FRB in consultations with the OCC and the FDIC (over July and August 2014).[9] The scenarios consisted of the future paths of 28 economic and financial variables (six measures of economic activity and prices, four measures of developments in equity and property prices, six measures of interest rates and variables for the euro area, the United Kingdom, developing Asia, and Japan).

33. The baseline scenario and the stress scenario over the initial three years reflected the supervisory baseline scenario and the severely adverse scenario under the Dodd-Frank Act Stress Tests (DFAST), respectively. The baseline scenario was very similar to the IMF's latest WEO projections for the first three years of the horizon. The stress scenario reflected the severely adverse scenario under the DFAST[10] for the first three years of the forecast horizon (up to 2017Q4). The

[9] See Board of Governors of the Federal Reserve System: 2015 Supervisory Scenarios for Annual Stress Tests Required under the Dodd-Frank Act Stress Testing Rules and the Capital Plan Rule, October, 2014.

[10] Overall, the 2015 and 2014 DFAST severely adverse scenarios were very similar. The real GDP growth rate dynamics over the stress horizon (in terms of standard deviations) in 2015 and 2014 exercise were almost the same. The same applied to 28 other variables. There were two main differences between the 2015 and the 2014 DFAST exercise. First, the 2015 DFAST included wider corporate bond spreads, reflecting a general pullback from a variety of assets linked to risky corporate borrowers (high-yield bonds, leveraged loans, CLOs). The spreads widened to levels reached in the 2008 recession. Second, a larger increase in the price of oil (to $110 per barrel) was assumed. This led the CPI headline inflation rate to reach 4.2 percent in the short run, before falling back to 1.6 percent by the end of the DFAST horizon. Market shock calibration was broadly similar to the 2014 exercise. In the adverse scenario a positive shock to short-term interest rates was used in the 2015 DFAST, in order to explore the sensitivity of the financial system to uniquely different stresses than those reflected in the severely adverse scenario.

scenarios were characterized by 10 variables from the DFAST and three additional variables not included in the DFAST (Table 3).

34. For the first three years of the horizon (from 2014Q4 to 2017Q4), the IMF staff adhered to the supervisory scenarios. For the additional years (from 2018Q1 to 2019Q4), the paths for a selected subset of key indicators (GDP growth, unemployment, short- and long-term interest rates) were extended based on the latest WEO projections for the baseline. For the stress scenario, the paths for the key indicators were extended so as to converge to the baseline by the end of the horizon. The other variables from the DFAST (house prices, commercial real estate prices, VIX, Dow Jones stock price index, BBB corporate yield and mortgage rates) were extended using simple OLS regression models and projections for key indicators as exogenous variables (Table 3). Business and consumer interest rates[11] and federal funds rate were added to the set of variables from the DFAST and were projected from 2014Q4 using regression models and projections of variables from the DFAST.

Table 3. Variables Used in the IMF Stress Test

Variables used in the ST	Projected from	Exogenous variables
Real GDP growth Unemployment rate 3-month Treasury rate 10-year Treasury yield	2018q1	Extended to converge to the baseline by the end of the horizon
BBB corporate yield		Differenced unemployment rate, real GDP growth, VIX, 10-year Treasury yield
Mortgage rate		Differenced unemployment rate, real GDP growth, VIX, 3-month Treasury rate, 10-year Treasury yield
Dow Jones Total Stock Market Index ((y/y))	2018q1	Differenced unemployment rate, real GDP growth, real GDP growth squared, VIX, 3-month Treasury rate
House Price Index (y/y)		Mortgage rate, y/y real GDP, y/y house price index (-1)
Commercial Real Estate Price Index (y/y)		BBB corporate yield, y/y real GDP, y/y CRE index (-1)
Market Volatility Index (Level)		Differenced unemployment rate, real GDP growth, real GDP growth squared
Variables added		
Business interest rates		10-year Treasury yield
Consumer interest rates	2014q4	Differenced unemployment rate, 10-year Treasury yield
Federal funds rate		3-month Treasury rate

Source: IMF Staff.

35. The baseline scenario was very similar to the average projections of economic forecasters.[12] It reflected a sustained, moderate expansion of U.S. economic activity converging to a

[11] Finance rate on personal loans at commercial banks (24 month loan) were used as consumer interest rates and bank prime loan rate was used as business interest rates.

[12] For example, the path for U.S. real activity and inflation was in line with the October 2014 consensus projections from Blue Chip Economic Indicators.

growth rate of about 2 percent and unemployment rate reaching 4.4 percent by the end of 2019. Gradual normalization in federal funds rate and Treasury yields starts in second quarter of 2015. Interest rates on mortgage loans, consumer loans and business loans follow broadly the dynamics of short-term rates. All assets prices (equity, house and commercial property) rise steadily accompanying the modest expansion of economic activity.

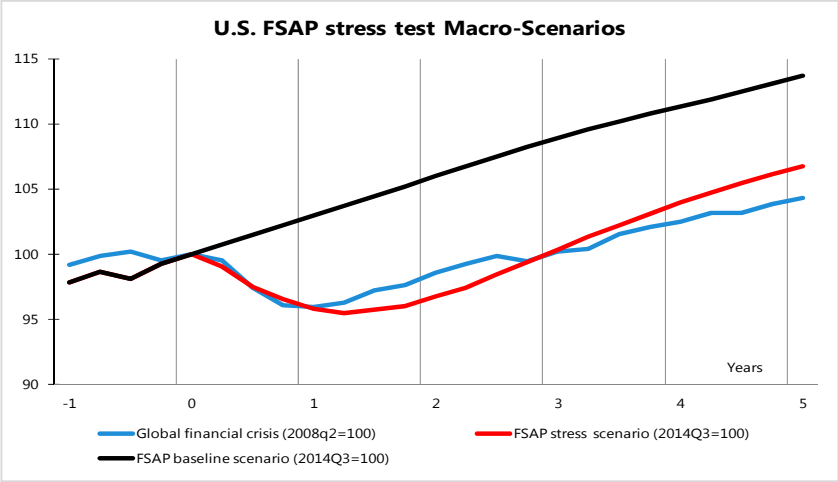
36. The stress scenario was similar in severity to the 2007–09 recession. The stress scenario was based on the severely adverse scenario of the DFAST, which was deemed appropriately stressful from the FSAP viewpoint. Nonetheless, the scenario horizon was expanded to 5 years, bringing it closer to recent FSAPs. Following the approach adopted in the DFAST, the trajectories and co-movements of key variables were informed by post-war U.S. recessions, with scenario severity calibrated to be similar to the 2007–09 recession. The unemployment rate was used as the primary basis for specifying the scenario[13] and the other variables were set using a combination of economic models, typical paths of these variables in past recessions, and informed judgment.[14] The severely adverse scenario in the 2015 DFAST (the shock was applied from 2014Q4) was characterized by a 4 percentage point rise in the unemployment rate over a two-year period. It was assumed that: real GDP would be on average 6.6 percentage points lower than the baseline in 2015 (Figure 2);[15] equity prices would fall by 60 percent in the first year; house prices would decline by 25 percent over the first two years; corporate spreads would rise significantly in 2015, reflecting a deterioration of U.S. corporate credit quality; mortgage rates would increase by 80 basis points; and market volatility would rise to levels the same as the peaks reached in the 2007–09 recession. Short-term interest rates would remain at zero by end of 2017, reinforcing the negative effects from protracted period of low interest rates, after which normalization would start. Long-term Treasury yields would first drop to 1 percent in 2014Q4 and then edged up slowly over the remainder of the stress testing horizon. The scenario also included a rise in oil prices to about $110 per barrel possibly reflecting a materialization of geopolitical risks. After 2017, most of the variables were assumed to converge to the levels in the baseline scenario. The stress scenario was complemented with sensitivity analyses to estimate the marginal impact of individual risks not captured by the scenario (the interest rate spike in particular). The supervisory DFAST calculations of net income losses also incorporated projected losses generated by operational risk events such as fraud, computer system, or other operating disruptions.

[13] After specifying the unemployment rate, the FRB specified paths of other macroeconomic variables based on the paths of unemployment using models or how these variables have typically evolved in the past U.S. recessions and informed judgment as some variables have taken divergent paths in previous recessions. FRB staff believes that this approach is more suited for developing the severely adverse scenario than a probabilistic approach, which is model dependent.

[14] See "Policy Statement on the Scenario Design Framework for Stress Testing," 12 CFR 252, appendix A.

[15] GDP growth rates were negative for 5 quarters, implying a 4.6 percent cumulative loss of real GDP from 2014Q3 to 2015q4. The projected dynamics follows that of GDP growth in the 2008 recession, which was the worst post-war U.S. recession in terms of output and employment losses and its duration. The cumulative loss of real GDP during the 2008/2009 crisis was 3.6 percent from 2008Q3 to 2009Q2.

Figure 2. GDP Growth in the Baseline and Stress Scenario



Source: FRB, IMF Staff calculations.

D. Capital Standards

Capital definitions

37. The capital definition applied in the stress test corresponded to Basel III capital standards. This was applied to all BHCs, recognizing that only advanced approaches BHCs were subject to Basel III capital rules in 2014, and non-advanced approached BHCs became subject to the rules from January 1, 2015.

38. Hurdle rates included the CET1 minimum requirement, the capital conservation buffer, and the GSIB surcharge. The solvency stress test assessed the level of BHCs common equity Tier 1 ratios of both advanced approaches and non-advanced approaches BHCs against the regulatory threshold consistent with the Basel III transition schedule but also accounting for capital conservation buffer and a G-SIBs capital surcharge (calculated using the BCBS framework), as minimums (Table 4). The phase-in for the Basel III framework that began during 2014 and the revised capital framework that introduced a new standardized approach to RWAs starting in 2015 were also considered (Table 5). A common equity surcharge associated with G-SIB status was also taken into account. It ranged from 1.0 to 2.5 percent, following Financial Stability Board (FSB) buckets corresponding to required level of additional loss absorbency, and it was phased-in between January 1, 2016 and end of 2018.[16,17]

[16] The FRB has invited comments on a proposal to establish a GSIB surcharge for U.S. BHCs that is based on the BCBS methodology, augmented to address specific risks to U.S. financial stability. Under the proposal, estimated surcharges for BHCs that would be identified as GSIBs currently would range from 1.0 to 4.5 percent of a firm's total risk-weighted assets, as compared from buffers that range from 1.0 to 2.5 percent, under the BCBS methodology.

[17] The impact on a leverage ratio defined as Tier 1 capital ratio over total assets was also considered but were not reported. The results related to the leverage ratio confirmed the results based on risk sensitive capital measures since BHCs have to calculate risk-weighted assets using the standardized approach (or generalized approach in the past). Analyzing the Basel III leverage ratio would require forecasting off-balance sheet items (derivatives exposures, securities financing transaction exposures and other off-balance sheet items) which was out the scope of this stress testing exercise due to lack of granular data for off-balance sheet exposures.

Table 4. Capital Standards (percent)

	2014	2015	2016	2017	2018	2019
I. Basel III phase-in minimum CET1	4.0	4.5	4.5	4.5	4.5	4.5
II. Capital conservation buffer			0.625	1.250	1.875	2.5
III. Total CET1 ratio (I.+II.)	4.0	4.5	5.125	5.750	6.375	7.0
IV. GSIB surcharge \1			0.25	0.50	0.75	1.00
V. Total CET for GSIBs (III. + IV.)	4.00	4.50	5.375-5.75	6.25-7.0	7.125-8.25	8.0-9.5
Phase in of deductions from CET1 \2	20	40	60	80	100	100
Phase out of existing AOCI capital adjustments \3	80	60	40	20	0	0

\1 GSIB surcharge factor (the factor was multiplied by GSIB surcharge).
\2 Applied to intangible assets and DTAs.
\3 For advanced approached BHCs only.
Source: FRB, IMF Staff.

Table 5. Capital Standards for Advanced Approach BHCs and Other BHCs

Capital Ratio	Aspect of the Ratio	Q4 2014	2015	2016 onwards
Advanced approaches BHCs				
Common equity tier 1 ratio	Capital in numerator	Revised (Basel III) capital framework	Revised (Basel III) capital framework	Revised (Basel III) capital framework
	Denominator	General approach RWAs	Projected RWAs, stand. RWAs switch, include op. risk RWAs	Projected RWAs, include op. risk RWAs
Tier 1 leverage ratio	Capital in numerator	Revised (Basel III) capital framework	Revised (Basel III) capital framework	Revised (Basel III) capital framework
	Denominator	Average assets	Average assets	Average assets
Other BHCs				
Common equity tier 1 ratio	Capital in numerator	n/a but Basel III ratio estimated	Revised (Basel III) capital framework	Revised (Basel III) capital framework
	Denominator	General approach RWAs	Projected RWAs, stand. RWAs switch	Projected RWAs
Tier 1 leverage ratio	Capital in numerator	Basel I-based but Basel III used	Revised (Basel III) capital framework	Revised (Basel III) capital framework
	Denominator	Average assets	Average assets	Average assets

Source: FRB, IMF Staff.

39. CET1 capital for the base period was estimated for non-advanced approaches BHCs. Non-advanced approaches BHCs became subject to Basel III capital rules from 2015Q1 and did not report CET1 capital (on Schedule HC-R, Part I.B. of FR Y-9C) as of September 2014. Therefore, SNL's estimate of CET1 (after deductions and adjustments) were used. SNL calculates the CET1 as: Tier 1 Capital - Non-qualifying Perpetual Preferred Stock - Preferred Stock & Surplus - Qualifying: Non

Controlling Interests—Qualifying: Restricted Core Capital Elements—Qualifying: Mandatory Convertible Securities.[18]

40. Deductions from CET1 were needed to calculate phase in of deductions from CET1. Most deductions pertained to goodwill, intangible assets, and deferred tax assets (DTAs).[19] To calculate phase in of deductions from CET1 the following strategy was implemented:

- The deductions were reported by the advanced approaches BHCs only (in Schedule HC-R). For non-advanced approaches BHCs intangible assets deducted from CET1 were approximated by intangible assets other than goodwill and mortgage servicing assets (MSA) (from Schedule HC-M) adjusted for deferred tax liabilities (DTLs) associated with intangible assets.[20] A deduction related to goodwill, net of deferred tax liabilities, were reported by all BHCs. A deduction related to DTAs for non-advanced approaches BHCs was approximated by DTAs deducted from Tier 1 capital.

- The nominal value of all deductions was assumed to stay constant over the stress testing horizon (as in the supervisory DFAST). Each deduction had to be considered separately since there was no transition provision for goodwill while intangible assets and DTAs followed the Basel III transition provisions.[21] Deductions were calculated by multiplying intangible assets and DTAs by the transition provision factor. Only the difference between the deduction in period t+1 and t was subtracted from CET1 capital in period t since CET1 in period t was already defined as CET1 after adjustments and deductions.[22] No assumptions were made about banks' behavioral responses to phase-ins.

41. The treatment of accumulated other comprehensive income (AOCI) reflected the Basel III transition arrangements. Consistent with Basel III transition arrangements, only 20 percent of AOCI was incorporated into CET1 capital in 2014 and additional 20 percent in every year after 2014[23] for advanced approaches BHCs. Consistent with the supervisory DFAST, it was assumed that non-advanced approaches BHCs would opt out of including AOCI. In comparison to Fed's stress test that

[18] SNL's estimates of CET1 capital were very similar to pro-forma estimates of CET1 reported by non-advanced approaches BHCs in their financial reports.

[19] Other adjustments and deductions account, on average, for 3.2 of total deductions or 0.3 percent of CET1 after adjustments and deductions.

[20] It was assumed that, for non-advanced approaches BHCs, the same proportion of intangible assets is related to deferred tax liabilities associated with intangible assets which was equal to average share of DTLs associated with intangible assets for advanced approaches BHCs (defined as the difference between intangible assets other than goodwill and MSA (from Schedule HC-M) and non-phase in value of intangible assets deducted from CET1 (from Schedule HC-R).

[21] The amount for intangible assets, and DTAs reported in Schedule HC-R (BHCA P842, P843) in 2014Q3 were already a result of applying transition provisions in 2014 (20 percent).

[22] In other words, what matters for CET1 is the marginal effect of higher transition provision factor.

[23] No assumptions were made on possible behavioral assumption of BHCs with respect to transition provisions such as the fact that BHCs might reallocate their securities portfolio from AFS to HTM as higher proportion of AOCI flows through to CET1 capital.

held the components of AOCI other than unrealized gains (losses) on AFS securities constant over the planning period, in the IMF top-down test the aggregate AOCI was modeled as the structure of AOCI is not publicly available information. As in the case of deductions, only the difference between AOCI in period t+1 and t was added to CET1 capital in period t since CET1 in period t was already defined as CET1 after AOCI.

Risk-weighted assets

42. Total risk weighted assets (RWAs) were projected for each BHC that participated in the stress test. The two components of RWAs (credit RWAs for total assets and off-balance sheet items and market RWAs[24]) were challenging to model separately with publicly available data,[25] and making simplified assumptions about each component of total RWAs could yield misleading results.[26] Nonetheless, the dynamics of total RWAs followed closely the dynamics of total assets which was projected in the exercise. Therefore, the year-on-year growth rate of total RWAs was modeled in a panel regression model with fixed effects as a function of year-on-year growth rate of total assets. Interest rates were added as an exogenous variable to reflect the assumption that the credit portfolio's underlying risk features does not remain constant[27] throughout the horizon thereby making the projection of RWAs risk sensitive. While BHCs can qualify for using the advanced approach credit risk RWAs from January 1, 2016,[28] it was assumed that the relationship between RWAs and total assets found before 2016 would hold also after 2016.

43. Operational risk RWAs were included in calculation of total RWAs for advanced approaches BHCs that exited the parallel run, given the requirements of the Collins amendment.[29] Operational risk capital charge for non-advanced approaches banking organizations and advanced-approaches BHCs that have not exited the parallel run was not applied. Since there

[24] Capital standards require all BHCs with significant market risk to measure their market risk exposure and hold sufficient capital to protect against the risk of loss attributable to this exposure. In general, a bank holding company is subject to the market risk capital rules if its consolidated trading activity, defined as the sum of trading assets and liabilities as reported in its FR Y-9C report for the previous quarter, equals: (1) 10 percent or more of the bank holding company's total assets as reported in its FR Y-9C report for the previous quarter, or (2) $1 billion or more. A bank holding company's measure for market risk for its covered positions is the sum of its value-at-risk (VAR)-based, stressed VaR-based, incremental risk, and comprehensive risk capital requirements plus its specific risk add-ons and any capital requirement for de minimis exposures. A BHC's market risk equivalent assets equal its measure for market risk multiplied by 12.5 (the reciprocal of the minimum 8.0 percent capital ratio).

[25] The initial objective was to calculate credit RWAs based on the projection of BHCs' total assets and the average risk weight computed using total asset and total credit RWAs and holding these weights over the stress horizon constant. This would have, however, required modeling credit RWAs for off-balance sheet items (that depend on off-balance sheet items) and market RWAs, which was challenging due to RWAs' volatility.

[26] Shares of market RWAs or credit RWAs for off-balance sheet items in total RWAs, credit RWAs for balance sheets, total assets or nominal GDP are not stable over time.

[27] For example, borrowers might become riskier as the debt burden becomes larger due to higher interest rates.

[28] The standardized approach to calculate RWAs is used to establish the minimum "generally applicable" capital floor requirements—a BHCs has to calculate RWAs using both standardized and advanced approach but is required to use higher RWAs (under the Collins amendment) for calculation of capital requirements.

[29] A capital charge for operational risk was not reported in FR Y-9C report. Advanced approaches BHCs that exited parallel run report this charge on FFIEC 101 report, Schedule B, item 35.

was no meaningful way to project RWAs for operational risk, it was assumed that the share of operational RWAs in total assets stays the same over the stress testing horizon. RWAs for advanced approaches BHCs that exited the parallel run were projected without operational RWAs. Projection of operational RWAs was then added to projected RWAs to calculate projected total RWAs.

44. The increase in risk weighted assets due to the implementation of standardized approach was applied to projected total RWAs.[30] Credit RWAs under the standardized approach were not possible to calculate as publicly available data were not granular enough to apply the new weights to calculate credit RWAs.[31] The increase in credit risk RWAs, due to introduction of standardized approach, was applied in 2015 onwards based on the calculated average increase in RWAs reported for the 2014 DFA stress testing exercise.[32] The average increase of RWAs due to implementation of standardized approach was 9 percent which is in line with BCBS Basel III monitoring exercise estimates of RWA changes due to Basel III rules, as per Table A.13 in BCBS (2014).[33]

E. Models and Behavioral Assumptions

45. Quarterly data from 1991 to 2014Q3 from FR Y-9C report and a set of panel regression models were used to forecast each BHCs' main components of balance sheets and income statements (Figure 3).[34] Projections of balance sheets (Step 1, Table 8) over the stress testing

[30] As of 2014Q3, in the FR Y-9C report, Schedule HC-R, Part II., BHCs were required to report risk-weighted assets using general approach only. Credit RWAs for BHCs were calculated under the general approach in 2014, and under the standardized approach from January 1, 2015.

[31] The main differences in weights between the Basel I general approach to RWAs and the Basel III standardized approach to RWAs are: risk weights for exposures to foreign governments depend on the sovereign's OECD country risk classification (0–150 percent instead of 0, 20 and 100 percent), to certain supranational entities and multilateral development banks (0 percent instead of 20 percent), exposures to public sector entities depend on the sovereign's OECD country risk classification (20-150 percent instead of 20, 50 and 100 percent), exposures to foreign banks depend on the sovereign's OECD country risk classification (20-150 percent instead of 20 and 100 percent), exposures to qualifying securities firms (100 percent instead of 20 percent), high volatility CRE loans (150 percent instead of 100 percent); exposures to OTC derivatives (50 percent risk weight ceiling is removed); approach to calculating RWA for securitization exposures, collateralized transactions, cleared derivatives, equity exposures to investment funds, unsettled transactions amended, equity exposures (0–600 percent instead of 100 percent).

[32] The range of RWA increases was wide which could have introduced a bias in the forecast of RWAs.

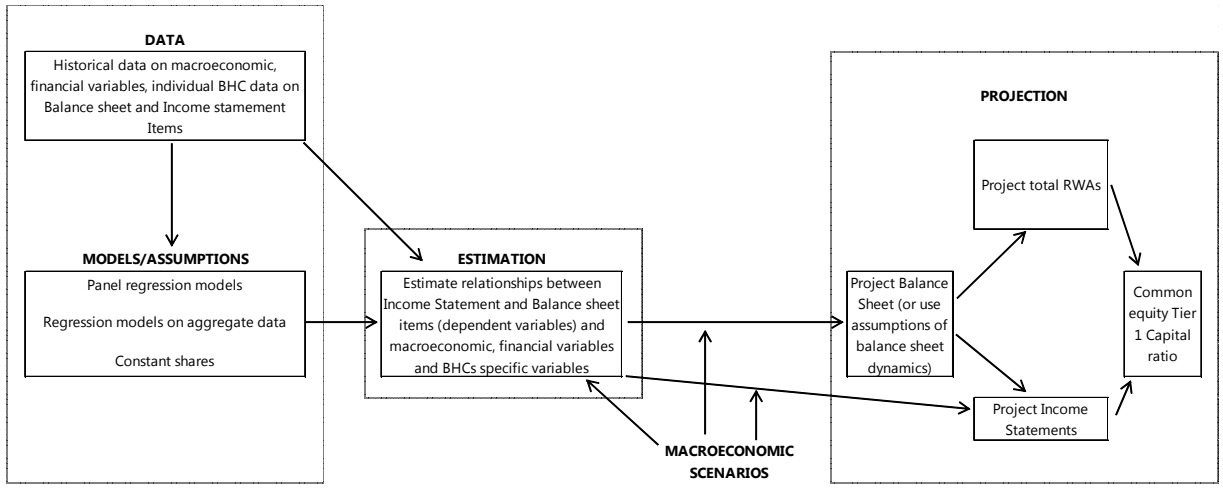
[33] The latest BCBS's Basel III monitoring exercise estimates the increase in total RWAs to be 8.3 percent for Group 1 banks and 6.5 percent for Group 2 banks.

[34] When projecting each item, several approaches were considered for robustness purposes. Lags of dependent variable, of independent variables, fixed effects versus pooled estimates and different definitions of dependent variables (year-on-year, q-o-q and shares) and the impact of outliers were explored. The initial set of potential regressors for each model was chosen on the basis of economic intuition or evidence from the literature. The "best" model was chosen based on R^2 as well as the sign of estimated coefficients and its statistical significance. Some variables were not included in the model (despite economic logic) due to multicollinearity and/or their marginal contribution to higher R^2 when included in the model. Many models perform best with variables specified as year-on-year growth rates. While R^2 was always higher in a specification with lagged dependent variable only one equation (the loan equation) has a lagged dependent variable. The disadvantage of using lags of dependent variable might be that the autoregressive term creates too much persistence at the time when the economy turns and might not produce effects large enough to reflect that turn. Moreover, the lagged term might take over most of the explanatory power over other explanatory variables rendering them useless for the stress testing purposes. Lagged dependent variables were only considered in cases where it was reasonable to expect that dependent variable might

(continued)

horizon were used for the purposes of projecting total RWAs and income statement items (Step 2). Projections of RWAs and net income, with assumptions on dividend distribution, Basel III deductions and AOCI determined capital requirements over the stress testing horizon (Step 3). In comparison to the DFAST, asset disposals and acquisitions over time were not considered.

Figure 3. IMF Stress Testing Framework: Bank Solvency



Source: IMF Staff.

46. The models used were intended to capture how the balance sheet, RWAs, and net income of each BHC are affected by the macroeconomic and financial conditions (that served as independent variables) described in the scenarios. In those cases where the panel modeling approach was not appropriate, due to highly volatile individual bank data or insignificant relationships with macroeconomic and financial variables, modeling the particular variable at the aggregate level was tried. Projections of aggregate variables were then distributed to each BHC based on their market share or 2014 DFAST results.

Balance sheet growth projections

47. The growth rate of total assets was assumed to be equal to the growth rate of the largest asset category, accounting for smaller volatility of the growth rate of total assets.[35] In most

exert some persistence even in the event of a shock (e.g. loans). Outliers from the loan equation, net interest expense, net interest income, net charge offs equations, which for the loan equations and net charge-offs equations had an important impact on estimated results, were taken out from the sample. Outliers were not taken out from equations for trading, provisions, AOCI and non-interest incomes since stress testing is focused on tail events and in these cases statistical outliers should not be removed from the sample. For the same reason, using techniques such as winsorizing the top and bottom 5 percent seemed as too blunt an instrument to address issues related to outliers. Therefore, as a general rule, only a small number of extreme outliers where the specific data points could not be clearly explained, were taken out from equations (the outliers represented less than 1 percent of the sample size, except for the loan equation, where a slightly higher proportion of outliers was taken out).

[35] Year-on-year growth rates of total assets were "filtered" and projected using pooled panel regression model with year-on-year growth rate of loans as the only independent variable.

cases, this meant that assets grew in line with total loans. In several cases, that meant that assets grew in line with trading assets. The projection of BHCs' total assets and loans was used for projecting income statement items and RWAs.[36]

48. Modeling individual BHC's total loans proved to be more straightforward than modeling each loan portfolio item (residential real estate, CRE, business loans, consumer loans, loans to foreign governments, loans to financial institutions and other loans, Table 6 and 7).[37] A panel, fixed-effects model of a year-on-year growth rate of net total loans was estimated and projected at the bank by bank level. It was assumed that lower economic activity, increases in interest rates and higher market turbulence (as a proxy for risk aversion) would lower the demand for loans. Therefore, independent variables included: year-on-year growth rate of real GDP, year-on-year changes in interest rates, and the VIX. The model also included lagged dependent variable to account for persistence in the growth rate of loans.[38] The growth rate of loans was used in projection of net interest income and total assets and deposits. Based on a strong historical relationship between year-on-year growth rates of loans and deposits (correlation equal to 0.85) it was assumed that the growth rate of deposits is equal to the growth rate of loans over the stress testing horizon. In the sensitivity analysis different growth rates of loans and total assets (in line with Fed's top down approach) in the stress scenario were analyzed.

49. Total assets of Goldman Sachs and Morgan Stanley were primarily determined by the dynamics of their trading assets, which were projected separately.[39] Trading assets were projected in a panel regression with fixed effects where year-on-year growth rate of trading assets of both companies were determined by VIX, real GDP growth rate, and the federal funds rate. The first two regressors were expected to control for factors that affect trading activity whereas the interest rates was included as a regressor to control for the effects on asset prices. The growth rates of total assets for the two companies over the stress horizon were assumed to be equal to the growth rate of projected trading assets.

[36] Other balance sheet items (cash, HTM securities, ATM securities, repos, trading assets and other assets) could not be consistently modeled with the available data, either on individual bank's (as year-on-year growth rates or as the share in total assets) or on aggregate data basis. That directly implied that projecting specific categories of credit risk RWAs was not possible and differences across BHCs' stress test results could not be explained by differences in the composition of their loan portfolio.

[37] Federal Reserve staff suggested that loans secured by owner- occupied nonfarm nonresidential properties should be classified as business loans and rather than CRE loans. However, many BHCs reported the sum of loans secured by owner- occupied nonfarm nonresidential properties and loans secured by other nonfarm nonresidential properties but not the items separately. This is the reason why it was assumed that both loans type were CRE loans.

[38] To take into account that OLS estimator is inconsistent when lagged dependent variable is used as an explanatory variables the Arellano-Bond estimators and additional lags of dependent variables as instruments were used. Since the estimated coefficients were very similar to OLS estimates, the model estimated with OLS was used in the projection exercise.

[39] Data in FR Y-9C for both companies start from 2009. Data for total assets and trading assets were extended to 2004 using companies' quarterly financial reports.

Table 6. Balance Sheet Mapping

Balance Sheet (IMF mapping)	Balance Sheet (Schedule HC)
Assets	**Assets**
1. Cash and balances due from depository institutions (1.a. + 1.b.)	1. Cash and balances due from depository institutions:
2. Securities:	a. Noninterest-bearing balances and currency and coin
a. Held-to-maturity securities (2.a.)	b. Interest-bearing balances:
b. Available-for-sale securities (2.b.)	(1) In U.S. offices
3. Federal funds sold and securities purchased under agreements to resell (3.a. + 3.b.)	(2) In foreign offices, Edge and Agreement subsidiaries, and IBFs
4. Loans and lease financing receivables (items 4.a and 4.b minus 4.c: items a. trough f. minus g.):	2. Securities:
a. Residential real estate loans	a. Held-to-maturity securities (from Schedule HC-B, column A)
b. Commercial real estate	b. Available-for-sale securities (from Schedule HC-B, column D)
c. Business loans (items 4.a. + 4.b)	3. Federal funds sold and securities purchased under agreements to resell:
d. Consumer loans	a. Federal funds sold in domestic offices
e. Loans to financial institutions	b. Securities purchased under agreements to resell
f. Loans to foreign government	4. Loans and lease financing receivables:
g. LESS: Allowance for loan and lease losses (4.c.)	a. Loans and leases held for sale
5. Trading assets (5.)	b. Loans and leases, net of unearned income
6. Other assets (6.+7.+8.+9.+10.+11.)	c. LESS: Allowance for loan and lease losses
7. Total assets (sum of items 1 through 6)	d. Loans and leases, net of unearned income and allowance for loan and lease losses (item 4.b minus 4.c)
Liabilities	5. Trading assets (from Schedule HC-D)
8. Deposits:	6. Premises and fixed assets (including capitalized leases)
(1) Noninterest-bearing (13.a.(1)+13.b.(1))	7. Other real estate owned (from Schedule HC-M)
(2) Interest-bearing (13.a.(2)+13.b.(2))	8. Investments in unconsolidated subsidiaries and associated companies
9. Federal funds purchased and securities sold under agreements to repurchase (14.a.+14.b.)	9. Direct and indirect investments in real estate ventures
10. Trading liabilities (15.)	10. Intangible assets:
11. Other liabilities (16.+19.+20.)	a. Goodwill
12. Total liabilities (sum of items 8 through 11)	b. Other intangible assets (from Schedule HC-M)
Equity Capital	11. Other assets (from Schedule HC-F)
13. Perpetual preferred stock and related surplus	12. Total assets (sum of items 1 through 11)
14. Common stock (par value)	**Liabilities**
15. Surplus (exclude all surplus related to preferred stock)	13. Deposits:
16. a. Retained earnings	a. In domestic offices (from Schedule HC-E):
b. Accumulated other comprehensive income	(1) Noninterest-bearing
c. Other equity capital components	(2) Interest-bearing
17. a. Total holding company equity capital (sum of items 13 through 16.c)	b. In foreign offices, Edge and Agreement subsidiaries, and IBFs: BHFN
b. Noncontrolling (minority) interests in consolidated subsidiaries	(1) Noninterest-bearing
18. Total equity capital (sum of items 17.a and 17.b)	(2) Interest-bearing
19. Total liabilities and equity capital (sum of items 12 and 18)	14. Federal funds purchased and securities sold under agreements to repurchase: BHDM
	a. Federal funds purchased in domestic offices
	b. Securities sold under agreements to repurchase
	15. Trading liabilities (from Schedule HC-D)
	16. Other borrowed money (includes mortgage indebtedness and obligations under capitalized leases) (from Schedule HC-M)
	17. Not applicable
	18. Not applicable
	19. a. Subordinated notes and debentures
	b. Subordinated notes payable to unconsolidated trusts issuing trust preferred securities, and trust preferred securities issued by consolidated special purpose entities
	20. Other liabilities (from Schedule HC-G)
	21. Total liabilities (sum of items 13 through 20)
	22. Not applicable
	Equity Capital
	Holding Company Equity Capital
	23. Perpetual preferred stock and related surplus
	24. Common stock (par value)
	25. Surplus (exclude all surplus related to preferred stock)
	26. a. Retained earnings
	b. Accumulated other comprehensive income
	c. Other equity capital components
	27. a. Total holding company equity capital (sum of items 23 through 26.c)
	b. Noncontrolling (minority) interests in consolidated subsidiaries
	28. Total equity capital (sum of items 27.a and 27.b)
	29. Total liabilities and equity capital (sum of items 21 and 28)

Source: FRB, IMF Staff.

Table 7. Loan Portfolio Mapping

Column A (IMF mapping)	Column B (HC-C Schedule from FR Y-9C)
1. Real estate loans (1. from Column B)	**1. Loans secured by real estate**
a. Residential Real Estate (1.c. from Column B)	a. Construction, land development, and other land loans:
b. Commercial Real Estate (1.a.+1.b.+1.d.+1.e. from Column	(1) 1–4 family residential construction loans
	(2) Other construction loans and all land development and other land loans
2. Business loans (3. + 4. from Column B)	b. Secured by farmland
	c. Secured by 1–4 family residential properties:
3. Consumer loans (6. + 10. from Column B)	(1) Revolving, open-end loans secured by 1–4 family residential properties and extended under lines of credit
	(2) Closed-end loans secured by 1–4 family residential properties:
4. Loans to financial institutions (2. + 9. from Column B)	(a) Secured by first liens
	(b) Secured by junior liens
5. Loans to foreign governments (7. from Column B)	d. Secured by multifamily (5 or more) residential properties
	e. Secured by nonfarm nonresidential properties:
6. TOTAL (1. through 5.)	(1) Loans secured by owner- occupied nonfarm nonresidential properties
	(2) Loans secured by other nonfarm nonresidential properties
	2. Loans to depository institutions and acceptances of other banks
	a. To U.S. banks and other U.S. depository institutions
	b. To foreign banks
	3. Loans to finance agricultural production and other loans to farmers
	4. Commercial and industrial loans
	a. To U.S. addressees (domicile)
	b. To non-U.S. addressees (domicile)
	5. Not applicable
	6. Loans to individuals for household, family, and other personal expenditures
	a. Credit cards
	b. Other revolving credit plans
	c. Automobile loans
	d. Other consumer loans
	(includes single payment, installment, and all student loans)
	7. Loans to foreign governments and official institutions (including foreign central banks)
	8. Not applicable
	9. Loans to nondepository financial institutions and other loans:
	a. Loans to nondepository financial institutions
	b. Other loans
	(1) Loans for purchasing or carrying securities (secured or unsecured)
	(2) All other loans (exclude consumer loans)
	10. Lease financing receivables (net of unearned income)
	a. Leases to individuals for household, family, and other personal expenditures (i.e., consumer leases)
	b. All other leases
	11. LESS: Any unearned income on loans reflected in items 1–9 above
	12. Total (sum of items 1 through 10 minus item 11)

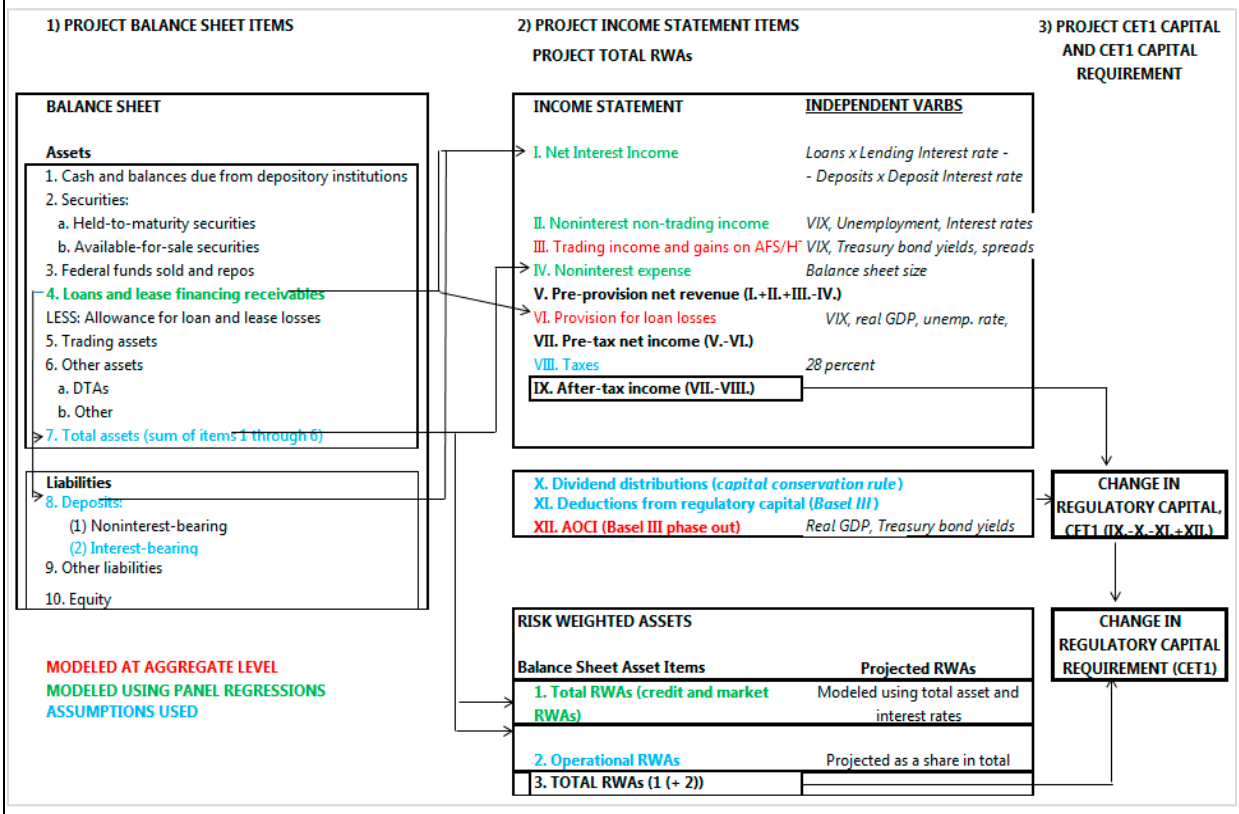
Source: FRB, IMF Staff.

Loan losses and net income projections: methodology

50. The projections of revenues, expenses, and loan losses were based on the IMF's projections of the balance sheet for each BHC over the planning horizon. Most components of pre-provision net revenue (including components of net interest income, noninterest income, and noninterest expenses, Table 8) were modeled using data on historical revenues and operating and other non-credit-related expenses reported on the FR Y-9C report in a simple panel regression

model framework (Tables 23 and 24).[40] Projections of all independent variables were taken from the scenarios.

Table 8. Projection Exercise



Source: IMF Staff.

51. Provisions for loan losses.

- In the first approach, which was used to calculate the results in the benchmark case, aggregate provisions were modeled as the ratio of total provisions over aggregate net loans as a function of real GDP growth, differenced unemployment rate, credit spreads, growth rates of house prices, growth rate of VIX[41] taking into account that effect on provision in

[40] The starting point for the choice of regressors in all the models was the New York Fed's CLASS model (Hirtle and others, 2014) and models of net charge-off rates in Francisco B. Covas, Ben Rump, and Egon Zakrajsek (2014). It was expected that higher GDP growth, falling unemployment, lower spreads, increases in house prices, and lower market volatility would lower provisions.

[41] It was expected that higher GDP growth, falling unemployment, lower spreads, increases in house prices and lower market volatility would lower provisions.

periods of stress are more pronounced.[42] Projected aggregate provisions were distributed among BHCs using individual bank's share of provisions in total provision in the 2014 DFAST exercise. This approach was used to benchmark projections of provision using other approaches as the model of aggregate provisions managed to capture the spike in provisions during 2008/2009 crisis.

- In the second approach, used in the sensitivity analysis, it was assumed—as in the last FSAP's stress testing exercise—that provisions are equal to net charge offs. Models of net charge off rates by loan types[43] that capture the historical behavior of net charge-offs over corresponding type of loans relative to changes in macroeconomic and financial market variables were considered (Table 9). The predicted net charge-off rates were multiplied by loan balances. The growth rate of each loan type was assumed to be equal to the projected growth rate of total loans. While there was a close relationship between provisions and net charge off rates during normal times, the disadvantage of this approach was that provisions increase more quickly than realized net charge-offs during stress times.[44] The IMF team's analysis showed that while the net charge offs dynamics compares well to the dynamics of provisions, they lag 2 to 3 quarters.[45] In the sensitivity analysis, the effect of projecting total net charge-offs and total provisions (instead of by loan types) was also explored.

52. Net interest income. Net interest income was projected using fixed effects panel regression and the annual difference of net interest income as the dependent variables and the annual difference of a product of total net loans and loan interest rates and the annual difference of a product of total interest bearing deposits and deposit rate[46] as explanatory variables. By including loans and deposits as an independent variable the macroeconomic environment as well as bank specific characteristics were taken into account. A projection of loans was taken from projection exercise of BHC's balance sheets and interest bearing deposits were assumed to grow at year-on-year growth rate of loans. Deposit interest rates were assumed to be equal to the Federal funds rate. For the purposes of estimation, the loan interest rate was defined as a weighted average of mortgage, business, consumption lending rate and federal funds rate that approximated the inter-banking interest rate adjusted for each BHC's loan portfolio structure.[47]

[42] This was modeled by including an interaction term between the growth rate of VIX and dummy variable which took value of 1 every time the growth rate of VIX was positive.

[43] Net charge offs for loans to government were not considered as they were very small in the last 15 years.

[44] Conversely, as the economy recovers provisions fall more quickly in advance of net charge-offs.

[45] This was taken into account when modeling and projecting net charge offs.

[46] These variables are the main determinants of net interest income.

[47] For each BHC, the weights were defined to reflect the structure of BHCs' loan portfolio (divided into real estate loans, CRE loans, business loans, consumer loans and loans to financial institutions, Table 7).

53. Non-interest income excluding trading income. This item was projected using a panel regression model with non-interest income (excluding trading income) over total assets as the dependent variable and the growth rate of VIX, unemployment rate and lending rates as independent variables. It was expected that during period of market turbulence (higher growth rates of VIX) trading from fees and commissions goes down as brokerage, underwriting, securitization fall. The same would be true if unemployment is high implying economic activity is low. Lending rates were included in the regression to control for substitution effect—it was expected that higher lending rates would make BHCs shift from non-interest income activities to interest income activities.

54. Trading income. Trading income was modeled as aggregate trading income that includes gains on AFS and hold to maturity (HTM) securities over total aggregate assets in a regression with the following independent variables: year-on-year growth rate of VIX, the interaction term between year-on-year growth rate of VIX and a dummy variable that took the value of 1 when the growth rate of VIX was positive to account for any non-linearity between market volatility and trading losses in times of stress, the change in credit spread[48] and the change in term spread. Projected trading income was distributed among BHCs based on their 2014 share of trading income and gains on AFS and HTM securities in total trading income that includes total gains on AFS and HTM securities.

55. Non-interest expenses. This item was modeled as a year-on-year growth rate in a panel regression with year-on-year growth rate of total assets as the only independent variable and fixed effects. The assumption was that non-interest expenses depend on the size of the business which is ultimately related to the size of the balance sheet.

56. Taxes. Taxes were set at 28 percent—the pooled average level of the tax rate over the last 25 years.

57. Extraordinary items and minority interest. It was assumed that these items are equal to zero as, in general, this item did not contribute much to the net income.

58. AOCI. Aggregate total AOCI[49] was modeled as the ratio of AOCI to aggregate assets in a regression with yearly change in BBB yields, 10 year Treasury bond, real GDP growth and the interaction term between real GDP growth and a dummy that takes value of 1 when GDP growth rate was negative to account for potential "non-linear" effects on unrealized losses in downturns. Projected total AOCI was distributed among BHCs using proportions of individual BHCs' AOCI losses in total AOCI losses in the 2014 DFAST exercise.

[48] Higher spreads were expected to signal lower profitability going forward.

[49] Granular data on AOCI and OCI components are not reported in FR Y-9C report.

Table 9. Models of Net Charge-Offs

Column A (IMF mapping of Schedule HI-B)	Column B Independent variable
1. Real estate loans (1. from Column B)	
a. Residential Real Estate	Real GDP, unemployment rate, house prices, mortgage rates, VIX
b. Commercial Real Estate	Real GDP, unemployment, CRE prices, corporate interest rates, VIX
2. Business loans	Unemployment, VIX, corporate spreads
3. Consumer loans (5. + 8. from Column A-Column B)	Unemployment, house prices, consumer interest rates
4. Loans to financial institutions	Real GDP, federal funds rate, VIX
5. TOTAL	Real GDP, unemployment rate, house prices, lending rates, corporate spreads

Source: IMF Staff.

59. The following income statement items were not considered: (i) losses related to operational risk events, mortgage repurchases, or OREO (ii) HFS/FVO loan losses as the data on these items were not publicly available and (iii) deferred tax assets (DTAs).

Capital action assumptions

60. A dividend distribution rule was defined where dividend distribution depends on the CET1 ratio. It was also assumed that BHCs do not issue new shares or make repurchases during the stress test horizon similar to the supervisory DFAST.[50] In comparison to DFAST assumptions on dividend payments where common stock dividend payments continue at the same level as in 2014, the following rule for determining dividend payments was assumed:

- Dividend payouts were payable out of the current year's profit using the Basel III capital conservation rule taking into account transition provisions and GSIB surcharge (Table 10). Dividends were assumed to be paid out of current period net income after taxes by BHCs that were in compliance with the capital requirement equal to the hurdle rate. A maximum allowed dividend payout was assumed to be equal to the dividend payout ratio (dividends over net income after taxes) in 2014. If a bank fell below the hurdle rate before dividend distribution, it was considered capital constrained and followed a schedule of dividend payouts per Table 10. If a bank fell below the hurdle rate because of dividend distribution, it was assumed that the bank's dividend payout was limited to a level that ensures the hurdle rate is not breached. This rule applied only if a bank earned a positive net income. If net

[50] In the supervisory DFAST it was assumed that BHCs can make new issuances related to employee stock ownership plans.

income was negative it was assumed that there was no dividend payout. If a bank was above the threshold it paid a maximum allowed proportion of dividend.

- In the sensitivity tests, an assumption that dividends remained fixed (in nominal terms) at their 2014 value was explored.

Table 10. Dividend Distribution Schedule[\1]

Capital ratio (CET 1): 2014	Capital ratio (CET 1): 2015	Capital ratio (CET 1): 2016	Capital ratio (CET 1): 2017	Capital ratio (CET 1): 2018	Capital ratio (CET 1): 2019	Assumed dividend payout
		4.5-4.656	4.5-4.813	4.5-4.969	4.5-5.125	0% x Net income (t)
		4.656-4.813	4.813-5.125	4.969-5.438	5.125-5.75	20% x EDPR x Net income (t)
		4.813-4.969	5.125-5.438	5.438-5.906	5.75-6.375	40% x EDPR x Net income (t)
		4.969-5.125	5.438-5.75	5.906-6.375	6.375-7.0	60% x EDPR x Net income (t)
>4.0	>4.5	>5.125	>5.75	>6.375	>7.0	Effective div. payout rate in 2014 (EDPR)

[\1] GSIB surcharge was also taken into account (not shown in the table).

Source: IMF Staff.

F. Sensitivity Analyses

61. To account for some of the differences between the IMF top-down stress test and the supervisory DFAST a range of sensitivity analyses were performed. These included: (i) assuming that loans and balance sheet grow at the similar rate as in the supervisory DFAST; (ii) assuming constant dividend distribution in the stress test like in the supervisory DFAST; (iii) assuming hurdle rates from DFAST and assuming that total RWAs are a sum of credit risk RWAs and market risk RWAs (and not including operational RWAs) and (iv) assuming all the elements of DFAST in the same scenario (constant dividends, fixed loan supply and total RWAs defined as a sum of credit and market RWAs only). Moreover, additional sensitivity analyses were performed: (i) including an oil price shock in the stress scenario; (ii) calculating the impact of a large interest rate shock in first year on the stress scenario; (iii) using different measures to calculate provisions in the stress scenario and (iv) extending the scope of the stress testing exercise to include all banking organizations with consolidated assets of $50 billion or more that are subject to Basel III capital requirements.

G. Results

62. The solvency stress test suggests that no BHCs would fall below the hurdle rate during the first year of severe economic distress (2015). This was due to high BHCs' capital position in the base year (11.7 percent) relative to the CET1 regulatory threshold (4.5 percent) and large profits in the base period. The system-wide CET 1 ratio fell by 2½ percentage points in 2015 (Figure 4) relative to the base year or 2.2 percentage points relative to the baseline scenario in 2015.

63. The results in the year of downturn were mainly driven by the increases in provisions and trading losses (Appendix Figure 5).

- Compared to the base period (2014Q3), the system wide CET1 remained intact in the first quarter of the stress testing horizon (2014Q4).[51] Net income fell sharply from its annualized, cumulative all-time high level in 2014Q3 of about $120 billion to a $30 billion net loss due to the impact of the initial negative shock in 2014Q4 on credit losses that doubled in comparison to 2014Q3 levels. On the other hand, lower RWAs due to slowdown in lending and total assets affected by the initial negative shock cushioned the negative effect of net losses on the CET1 ratio in 2014Q4. The modest negative impact of dividend distribution was not felt due to the capital conservation rule kicking in from 2014Q4 onwards.

- Provisions for credit losses and trading losses play the major role in dynamics of CET1 ratios in 2015. The lower CET1 ratio in 2015 was mainly a result of higher provisions, which were four times higher than at the end of 2014 (subtracting -2.3 percentage points from CET1 ratio which is 8 times higher than in the base period), trading losses (-0.6 percentage points), negative AOCI and higher deductions from CET1 (each contributing with -0.3 percentage points). Net interest income fell by 5 percent compared to the end of 2014 due to lower loan demand and despite higher spreads. Noninterest income also fell by more than 10 percent. The impact of the implementation of the standardized approach to calculate RWAs for credit risk (which raised total RWAs by about 9 percent in 2015) was cushioned by lower loans and total assets and RWAs stayed stable in comparison to 2014.

64. Two BHCs would fall below the hurdle rate in the first year of the recovery (2016). The system-wide CET1 would fall by additional 0.3 percentage points in 2016. One BHC fell below the hurdle rate mainly due to relatively low profitability in the baseline.

65. Eleven additional BHCs would fall below the hurdle rate by the end of the stress testing horizon due to "too rapid" expansion of their balance sheet. Notwithstanding the favorable economic environment, system-wide CET1 would fall by additional 0.6 percentage point in 2017–2018 after recovering in the last year of the stress testing horizon (by 0.1 percentage points). Despite a recovery in BHCs' capital position in 2019 a number of BHCs would fall below the hurdle rates. The BHCs that fell below the hurdle rate are the ones that on average had higher projected and historical (as reflected in the fixed effects in the loan equation) credit and total assets growth. Although this reflects the unrealistic assumption that BHCs would increase balance sheets even if this would take them below the regulatory threshold, this still suggests that these BHCs may need to raise additional capital if they are to be in a strong position to support a recovery in the face of an adverse scenario.

66. Changes in CET1 ratios in the recovery period were mainly driven by higher RWAs due to the expansion of BHCs' balance sheets.

[51] The CET1 ratio increased by ½ percentage points in the first three quarters of 2014 despite higher RWAs due to the implementation of Collins amendment for advanced approaches BHSs that exited the parallel run that lowered the CET1 by about 0.7 percentage points.

- The first year of the recovery (2016) was still characterized by net losses (after taxes) which together with higher RWAs and deductions from CET1 resulted in lower CET1 ratios. Provisions fell comparing to 2015 but stayed at relatively high level. Provisions and higher non-interest expense due to expansion of balance sheets primarily contributed to net losses. The growth rate of loans, total assets and RWAs picked up due to higher economic activity and lower market volatility that also contributed to higher non-interest income, including trading income.

- Higher RWAs weigh on CET1 ratios in the last three years of the stress testing horizon. While the cushioning impact of net interest income and non-interest income got stronger—reflecting the favorable economic environment—capital ratios deteriorated by increasing RWAs subtracting 80bps from CET1 in each of the last three years and increases in non-interest expenses due to the expansion of BHCs' balance sheets (by 10 percent annually). While provisions and deductions from CET1 still played a role, their impact became very small by the end of the stress testing horizon.

67. Recapitalization needs are manageable. Recapitalization needed to bring all BHCs to the hurdle thresholds peaks in 2019 at 180 percent of their annualized 2014Q1–Q3 net income—which corresponds to 1 percent of 2019 nominal GDP.

68. CET1 ratios were projected to fall in the baseline; this is driven by increases in the RWAs despite positive net incomes. The system-wide CET1 ratio fell by 90bps in 2019 comparing to the base period. The negative impact of higher RWAs and expansion in total assets due to favorable economic environment was larger than the positive impact of all time high profits reported by the BHCs in the period 2015–2017. The impact of higher RWAs throughout the stress testing horizon was reinforced by the implementation of the standardized approach in 2015. Moreover, the impact of net income got weaker from 2015 due to lower contribution of net interest income which came down as a result of tighter spreads and lagged effects of rising policy rates on lending rates. Dividend distribution played a role too, subtracting on average 40bps from CET1. Even under the baseline scenario 3 BHCs fell below the hurdle rate in 2018 and seven more in 2019. These are the same BHCs that failed the test under the stress scenario mainly due to rapid expansion of their balance sheets in the second part of the stress testing horizon.

69. Sensitivity analyses were performed with respect to loan and total assets dynamics, dividend distribution rule, oil price shock, interest rate shock and different models of provisions (Figure 4). The results show that:

- *Loan dynamics:* By using an assumption that loans and total assets do not fall during the period of downturn[52] CET1 ratios fall more in 2015 and less in subsequent periods. System-

[52] It was assumed that loans remain at their 2014Q3 level whereas total asset grow at the yearly rate of 2 percent. These growth rates are similar to DFAST assumptions.

wide CET1 ratio fell by additional 80bps due to higher RWAs when compared to the stress scenario but increased on average by 40bps a year in the last three years due to lower increases in RWAs resulting from lower growth rate in total assets then in the stress scenario.

- *Dividend distribution*: Holding dividends constant at their 2014Q3 level (as in the DFAST) would subtract additional 30bps from the system wide CET1 ratio each year.

- *DFAST hurdle rate, no operational RWAs:* Despite lower hurdle rates and higher initial capital ratios, the same two BHCs would fall below the thresholds. Additional 3 BHCs would fall below the threshold in the recovery period.

- *Constant loans and dividends, no operational RWAs:* The system wide CET1 fell by 380 bps in 2015. Under this scenario two additional BHCs would fall below the regulatory minimum of 4.5 percent mainly due to dividend distribution which, in the benchmark, are cut to zero due to negative net income in 2016.

- *Oil price shock:* Including oil prices as one of the determinants of provisions and applying the oil price shock where oil prices fell by 25 percent 2014Q4 and additional 60 percent by the end of 2015 would increase total provisions by around 3 percent.

- *Interest rate shock:* Applying the interest rate shock to the 3-month Treasury yields of 450bps in 2015 would not change the results significantly since higher short term rates would have both positive and negative effects on income statements and balance sheets. On one hand, higher short-term rates would reduce loans growth rate and subsequently total assets and RWAs. On the other hand, higher short-term interest rates would result in higher credit losses (by 11 percent in 2015) and losses on AOCI (almost twice as higher in 2014Q4–2015Q4 than in the stress scenario).[53] While these losses would be higher than in the stress scenario they would not be large enough to make a material impact on the results since the other variables have more pronounced effects on credit and trading losses than interest rates. However, the effects of higher interest rates on GDP growth were not analyzed.

- *Models of provisions:* The only model that can capture the spike in provisions in 2008/2009 is the model of aggregate provisions which projected provision in the period 2014Q4–2016Q4 at the level of $390bn. A panel model of total provisions and a panel model of net charge offs resulted in the same projection of total provision—$280bn over the same period. Comparing to the benchmark stress scenario, this would correspond to system-wide CET1 ratio increase of about 80bps in 2015 and 15bps in 2016. While panel models project lower

[53] A rise in short-term rate might also induce deposit outflows, something which is not captured by the stress testing framework. Moreover, the potential losses resulting from an interest rate shock due to cash-flow effects were not estimated due to data limitations.

provision in the first two years the projections are more persistent and results in higher total provision over the whole stress testing horizon than the model of aggregate provisions.

- *Structure of loan losses:* Modeling net charge-offs by loan type allows comparison of losses by loan type. An increase in credit losses is mainly driven by an increase in default rates and the size of exposures on the household sector. Around 35 percent of losses in 2015–2016 come from consumer loans and 25 percent comes from residential real estate exposures. While the share of commercial real estate and business loans is similar to 2008–2009, loans to financial institutions (and other loans) would account for much higher proportion of losses given their size in 2014 which is much higher than before the crisis.

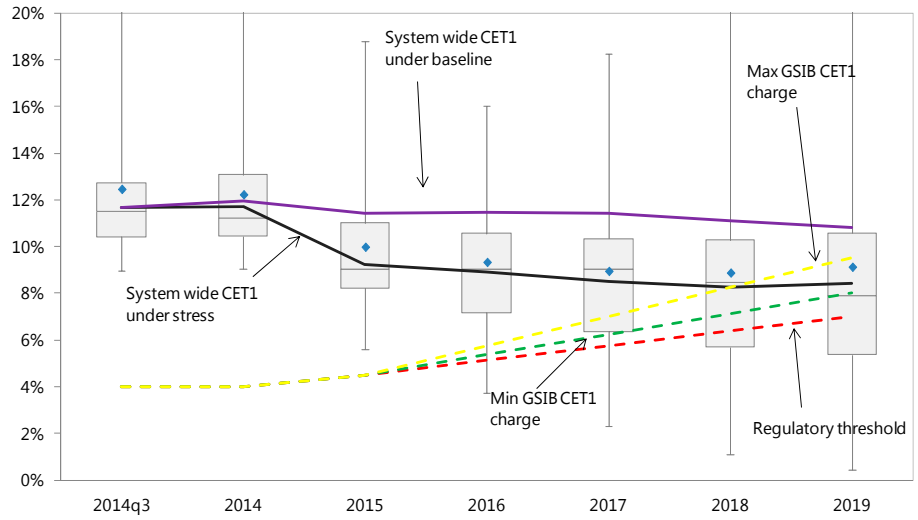
- *Expanded coverage of the stress test*: Expanding the coverage of the stress test to include all the deposit taking financial institutions with asset size of $50 billion and more that reported Basel III capital ratios as of 2014Q3 requires including additional two BHCs[54] and two large savings banks.[55] The same methodology was used to assess the capital adequacy of the four financial institutions as in the main stress test.[56] The results show that one financial institution would fall below the threshold in 2016 mainly due to higher provisions and relatively low capitalization in the base period. Total recapitalization needs would increase by 5 percent due to the recapitalization of this financial institution.

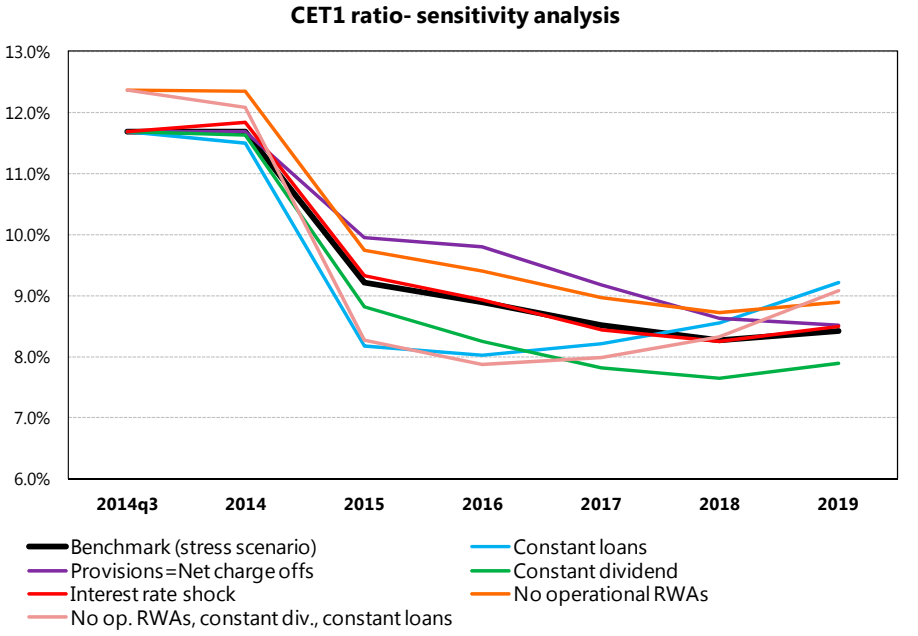
[54] These two banking organizations are subsidiaries of foreign banking organizations that are currently relying on Supervision and Regulation Letter SR 01-01 issued by the FRB. Supervision and Regulation Letter SR 01-01 generally provides that a U.S. BHC that is owned and controlled by a foreign bank that is a financial holding company that the Federal Reserve has determined to be "well-capitalized" and "well-managed" is not required to comply with the Federal Reserve's capital adequacy guidelines. Until July 21, 2015, the stress testing rule will not apply to any BHC that is a subsidiary of a foreign banking organization that is currently relying on Supervision and Regulation Letter SR 01-01. However, Section 171 of the Dodd-Frank Wall Street Reform and Consumer Protection Act requires that, commencing July 21, 2015, U.S. domiciled BHC subsidiaries of foreign banks may no longer rely upon SR-Letter 01-01.

[55] These two banks are part of large SLHCs.

[56] However, the provisions for loan losses were projected using the panel regression since the four financial institutions were not part of supervisory DFAST and projected total provisions could not be distributed based on their provisions' share in total provisions reported for the supervisory DFAST.

Figure 4. CET1 Ratio Under the Baseline and Stress Scenario





Note: The whisker boxes for each year display the distribution of CET1 ratios, projected using the IMF methodology, for 31 BHCs in terms of distribution's moments: the bottom and top of the whisker box are the first and third quartiles, the band inside the box is the second quartile (median), the diamonds represent an un-weighted average CET1 ratio for 31 BHCs, the lower and the upper whisker represent the minimum and the maximum CET1 ratio respectively. The system-wide CET1 ratios are defined as projected total CET1 capital over total RWAs (sum over all BHCs).
Source: IMF Staff calculations.

H. Network Analysis for Large BHCs

70. To assess potential spillovers among the six largest U.S. G-SIBs, FRB staff implemented an updated version of the network stress-test methodology developed in Espinosa and Solé

(2011). The network stress-tests were conducted by the staffs of the Federal Reserve Board (FRB) and the IMF in order to assess contagion risks among six U.S. BHCs designated as globally systemic.[57] This methodology consists of simulating credit and funding shocks within a network of institutions and then tracking the contagion effects in terms of capital losses and path of bank failures. In addition, the methodology also allows for the assessment of the systemic impact arising from existing off-balance sheet financial linkages (e.g., credit default swaps).

71. To preserve data confidentiality, Fund staff provided the FRB the software necessary to implement the network stress-tests but had no access to the actual data. In turn, the staff of the FRB ran several simulations and robustness checks for a range of model parameters. The output of these simulations was reported back to the Fund.

The data

72. The FRB maintains a dataset that was used to execute the Espinosa and Solé algorithm for six systemic BHCs in the United States. The confidential dataset contained information on these BHCs' capital levels, credit and funding exposures, as well as credit default swaps (CDS) contracts. The six institutions under consideration hold capital of around 9 to 12 percent of their total assets. Further details of the data are as follows:

- Credit exposure data: For each of the six BHCs the FRB has an estimate of the credit loss that would be borne if one of the other five institutions went into default. This credit exposure estimate incorporates both *direct credit losses*—i.e., the losses that result from the default on a loan—and *indirect credit losses*—i.e., which would include losses that result from replacing defaulted derivative positions and losses on owned securities that have been issued by the defaulting BHC.
- Funding exposure data: For each of the BHC, the FRB collects data on the amount of funding received from the other five counterparties. This amount includes secured and unsecured funding, as well as repo transactions of all maturities. Thus, the entire amount of a BHC's funding exposure represents an estimate of the total amount of borrowings that would have to be replaced by that BHC if the counterpart entered default.
- Risk transfer data: The FRB also has data on the amount of credit risk that has been transferred between the six BHCs. In particular, the data measure the amount of single-name notional CDS exposure that each bank has with respect to the five other BHCs in the sample (i.e., the notional amount of CDS protection that bank *i* has sold to bank *j* on reference entity bank *h*). Hence, note that the data do not include any CDS index trades nor does it contain data on more complex exposures such as CDS options.

[57] Eight companies are designated as GSIBs. Data were not sufficient to include the other two GSIBs in the exercise.

Simulation and results

73. The network stress-test exercise comprised four different sets of simulations designed to capture key dynamics at play during the 2007–08 financial crisis. The first set of simulations examines the domino effects triggered if each of the six BHCs defaulted (one at a time) on their respective credit commitments. The second set of simulations assesses the effects of a *credit-plus-funding* event, where the default of an institution also leads to a liquidity squeeze for those institutions funded by the defaulting institution. In this case, the credit shock is compounded by a funding shock and the associated fire sale losses.[58] The third and fourth sets of simulations build on the previous two by incorporating the credit default exposures of each BHC.[59] The simulations were conducted with quarterly data for each quarter between 2013Q1 and 2014Q3.

74. The results indicate that the six BHCs hold enough capital to sustain a range of credit and funding shocks to individual counterparties within the network. As reported by the FRB, most simulations did not trigger contagion chains among the six institutions under consideration. This result likely emerges from the fact that direct exposures within the six-BHC network are not large enough (relative to the initial capital of each institution) to lead to second-round spillovers. Nonetheless, the positive results are also suggestive of the need to expand the data on exposures included in the network (e.g., exposure of the six BHCs to money market funds), as well as consider richer market dynamics in the simulations (e.g., downward spirals in the value of certain financial assets).

75. The simulation results show that the six BHCs hold enough capital to sustain shocks to a single counterparty within the network. In the four simulations considered, all BHCs appear to have enough capital to sustain the credit and funding losses *individually* impinged by the other BHCs in the network. For example, Table 11 shows results for the credit-plus-funding shock with risk transfers: in all instances the capital losses born by each BHC are not large enough to trigger a second round of contagion. Nonetheless, the losses could be substantial for some BHCs (e.g., BHC 4 could suffer losses of up to 2.5 percent of its initial capital), and could in turn lead to further funding difficulties for that institution if market concerns arise given the relatively large loss of capital.

[58] When liquidity is tight and in the absence of alternative sources of funding, a bank may be forced to sell part of its assets in order to restore its balance sheet identity. The network stress-test replicates the situation where, as in the 2007–08 crisis, a bank is able to replace only a fraction of the lost funding and its assets trade at a discount (i.e., their market value is less than their book value). To err on the side of caution, the initial set of parameter values is arguably quite adverse. The simulations assumed that 35 percent of the funding provided by a defaulting institution cannot be replaced and that asset fire sales are conducted at 50 percent loss relative to book value. Finally, a bank is considered under distress if its capital to assets ratio falls below the prompt-corrective action (PCA) threshold of four percent.

[59] As illustrated below, contingent exposures such as credit default swaps deserve special consideration in times of stress because they activate dormant linkages across financial institutions and bring new exposures onto the balance sheet of an institution.

Table 11. Simulation Results of Credit and Funding Shock with Risk Transfers

United States: Simulation results of credit and funding shocks with risk transfers.

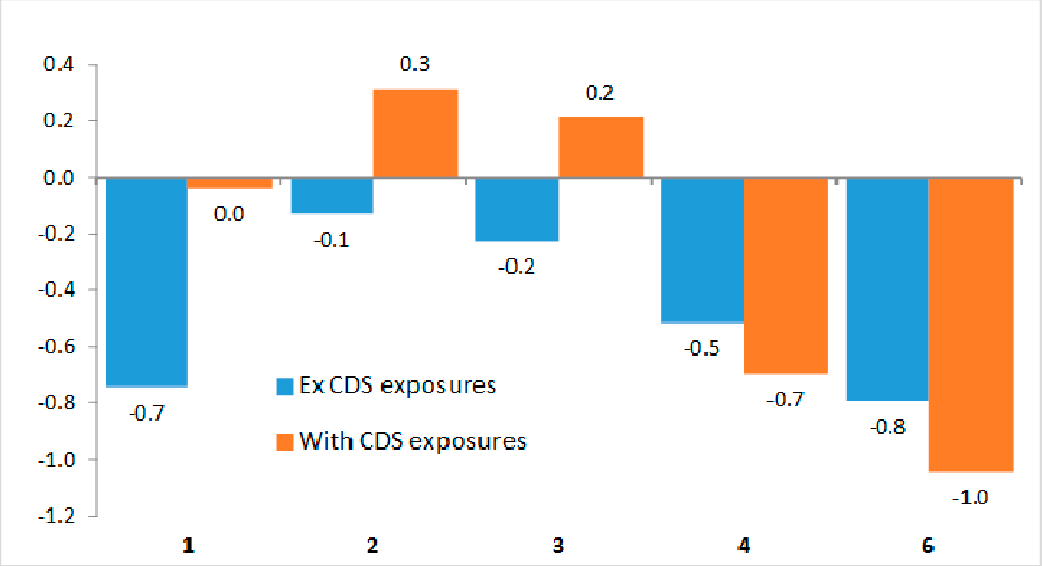
Q32014

		Loss Borne By Bank (% of initial capital)					
		1	**2**	**3**	**4**	**5**	**6**
Default of Bank	**1**		-0.5	-0.4	-2.5	0.0	-0.7
	2	-0.3		-0.2	-1.2	0.3	0.0
	3	-0.3	-0.8		-1.3	0.2	-0.5
	4	-0.4	-0.1	-0.5		-0.7	-0.6
	5	-0.4	-0.1	0.0	-0.3		-0.4
	6	-0.6	-0.4	-0.4	-1.0	-1.0	

Source: FRB, IMF Staff calculations.

76. The results also illustrate the importance of monitoring (and stress-testing) off-balance sheet exposures. Risk transfers such as credit default swaps can alter dramatically the risk profile of financial institutions. The simulations conducted allow an assessment of the potential impact that CDS exposures could have on each BHC's capital. Figure 5 shows, for example, that the losses to BHC 5 from the failure of each of its counterparties (one at a time) would be dramatically different depending on whether CDS are taken into account. The chart suggests that BHC 5 is actually hedging its exposures to BHCs 1, 2, and 3 via CDS, but that it is actually increasing its exposure to BHCs 4 and 6 via this market. This type of analysis could be useful to regulators to monitor the interaction between on- and off-balance sheet exposures.

Figure 5. Credit and Funding Shock



Note: Credit and funding shock – impact of CDS exposures on capital losses of BHC 5 (in percent of initial capital)

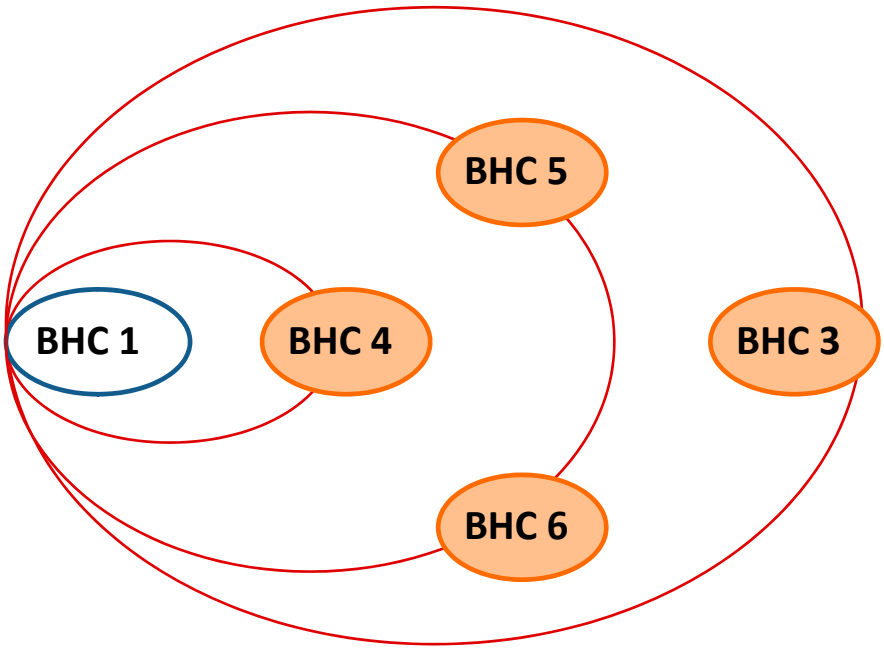
Source: FRB, IMF Staff calculations.

77. The results appear robust to further simulations with stressed values of the model's parameters. The FRB conducted robustness tests by assigning extreme values to the model's parameters that measure the severity of an institution's funding squeeze vis-à-vis the defaulting BHCs, the loss of asset value due to the fire sales associated with the funding squeeze, and by increasing the capital level below which an institution is considered under distress.[60]

78. Additional calculations by the FSAP team identified a combination of severe factors under which contagion would take place. A situation where funding markets are severely impaired and assets trade at heavy discounts could lead to a chain reaction of BHCs going into distress. For this severe scenario, the FSAP team assumed that only 65 percent of the short-term funding provided by a defaulting institution is rolled over by other market participants and that asset fire sales take place at 25 percent of book value. Given the team's lack of direct access to confidential supervisory information, it was assumed that all BHCs have initial capital levels equivalent to 8 percent of risk-weighted assets and that if a bank loses more than 5 percent of its initial capital in one round, it suffers "distress", which triggers the next round of contagion. Under these simplifying, though admittedly stark, assumptions, it is possible to trace which institutions would be more vulnerable through the contagion chain. For example, as shown in Figure 6, one such path would be triggered by distress in BHC 1 and would lead to three successive rounds of contagion affecting BHC 4 first, then BHCs 5 and 6 in a second round, and finally BHC 3. Note that BHC 2 would not go into distress in this scenario. These calculations are for illustration only, and more data on, for example, initial capital levels and exposure of the BHCs to specific financial instruments (e.g., reliance on short-term funding) to construct more accurate scenarios.

[60] The robustness tests include (i) assuming that none of the funding provided by the defaulting institution can be replaced (and hence larger sales of assets are needed), (ii) assuming that fire sales of assets take place at ¼ of the book value of the assets, and (iii) raising to 6 percent the capital threshold below which distress in one bank is transmitted to others.

Figure 6. Contagion Path Triggered by BHC 1 Distress



Source: IMF staff.

79. While somewhat reassuring, the results also point to the need to expand the FRB's dataset and consider richer market dynamics in the simulations. As explained, the FRB's dataset only includes data on direct exposures among the six systemic BHCs. Thus, the stress-tests are unable to assess the potential impact of contagion feedbacks arising from other segments of the financial sector (e.g., if the six BHCs are exposed to a common funding source prompt to runs, such as money market funds; or a common credit exposure, such as CDS contracts referenced to a beleaguered sovereign). Similarly, new simulations that comprise downward spirals in the value of certain financial assets (e.g., asset-backed securities) could be designed and added to the network stress-test. Fund and FRB staffs have held conversations in this regard.

DISCUSSION OF SUPERVISORY AND COMPANY-RUN SOLVENCY STRESS TESTS

80. This section summarizes the solvency stress tests conducted for the 2015 DFA stress testing exercise and discusses the differences vis-à-vis the FSAP team's analysis. The stress testing frameworks of both company-run DFAST and supervisory-run DFAST for the 31 BHCs are publicly available information. Details of the company-run solvency stress test for BHCs can be found in Board of the Governors of the Federal Reserve System, 2013, "Comprehensive Capital Analysis and

Review 2014 Summary Instructions and Guidance", November 2013 and Board of the Governors of the Federal Reserve System, 2013, "Capital Planning at Large Bank Holding Companies: Supervisory Expectations and Range of Current Practices", August 2013, whereas the details of the supervisory DFAST can be found in Board of the Governors of the Federal Reserve System, 2015, "Dodd-Frank Act Stress Test 2015: Supervisory Stress Test Methodology and Results", March 2015.

A. Supervisory Stress Tests

81. There are important differences between the IMF approach and the authorities' approach, with potentially significant impacts on results (Table 12). The hurdle rates in the IMF stress test were more stringent: there are differences in the calculation of risk-weighted assets, and capital ratios, such as the inclusion of operational RWAs in the IMF stress tests, that on average resulted in lower ratios for advanced approaches BHCs. The level of the granularity of the data and subsequently the methodology used by different approaches was different—the authorities used much more granular data. The dividend distribution rule used by the IMF was a function of the level of capital which was a less conservative assumption than the one used by the authorities. Loans and total assets were projected in the IMF stress test whereas they were forecasted conditional on the assumption that credit supply is maintained at long-run historical levels in the DFAST. Some losses were not covered by the IMF stress test due to lack of historical data. Finally, while the authorities used a 9-quarter stress horizon and 3-year forecast scenarios, the IMF test focused on stress testing horizon that spanned over 5 years. However, IMF forecasts over the first three years were consistent with the forecasts of the FRB under the baseline and stress scenarios.

Table 12. Main Differences Between IMF's Top-Down and FRB's Top-Down Approach

	IMF top down approach	Supervisory DFAST
Capital hurdle rates	Basel III minimum requirement+capital conservation buffer+GSIB surcharge	Basel III minimum requirement
Risk weighted assets	Includes operational RWAs for advanced approaches BHCs	Does not include operational RWAs for advanced approaches BHCs
Projected loans and total assets	Projected using a model	Forecasted conditional on the assumption that credit supply is maintained at long-run historical levels
Data used	Publicly available data	Granular supervisory data
Length of scenarios	5 years	9 quarters
One-time add-on shock	-	Global market shock and Counterparty shock
Important Income statement items not included	Losses related to operational risk events, mortgage repurchases, or OREO and HFS/FVO loan losses	
Dividend distribution	Dividend distribution rule as a function of capital ratio	Constant dividend at the 2014 level

Source: IMF Staff

82. An in-depth analysis of the results of the DFAST scenario is limited by constraints on publicly available information. Detailed information on capital, RWAs and income statement items were not publicly available. Only the minimum and the ending capital ratios over the stress testing horizon of nine quarter were published. RWAs were published as of the end of the stress testing horizon. Income statement items were published as a cumulative value of pre-provision revenue, other revenue, provisions, realized losses/gains on securities (AFS/HTM), trading and counterparty losses, other losses/gains, net income before taxes and other comprehensive income. AOCI included in capital was published as of the end of the stress testing horizon. Loan losses (cumulative over the nine quarter period) and loan losses structure was published by type of loan. All the results were presented both in the aggregate for the 31 BHCs and for individual BHCs for severely adverse and adverse scenario.

83. With this caveat, the results of the supervisory DFAST suggest that, in the aggregate, BHCs are resilient to shocks for the severely adverse scenario. All BHCs stay above the regulatory minima. Even if the IMF hurdle rates were used, no BHC failed the stress test. Over the nine quarter of the stress testing horizon the system-wide CET1 would fall to 7.6 percent (its minimum) and to 7.8 by the end of 2016. If compared to the IMF estimate of the system wide CET1 in 2014Q3 (of 12.4 percent) the CET1 ratio at its minimum would fall by 480 basis points, compared to 2014Q3. This is both due to increase in RWAs, which mainly reflects the implementation of standardized approach in 2015 and the assumption on the loan supply, as well as net income losses that were projected to be -$222 billion.

84. The losses were mainly driven by loan losses ($340 billion) and trading and counterparty credit losses from a global market shock ($103 billion). Projected losses on mortgage [61]and consumer loans[62] represent 56 percent of projected loan losses driven by higher unemployment rate and lower house prices. The largest losses pertained to credit card losses ($83 billion). The nine-quarter cumulative loss rate of 6.1 percent, with significant differences across BHCs, is high by historical standards and more severe than any recession since the 1930ties. Trading losses at the six BHCs and counterparty losses at the eight BHCs ranged between $1bn and $24 billion across the eight BHCs.

85. Low level of pre-provision revenue mainly reflected low projected net interest income and non-interest income. This is consistent with low interest rates and flattening of the yield curve in the first part of the stress testing horizon and falling asset prices, rising equity market volatility and falling economic activity.

86. Under the adverse scenario BHCs would report moderate declines in capital ratios. The adverse scenario simulates a mild recession but with a sharp increase in short term rates that affect BHCs' funding costs. The projected capital ratios are smaller than those under the severely adverse

[61] Mortgage loans were defined as first-lien mortgages, domestic and junior liens and HELOCs, domestic mortgage loans.

[62] Consumer loans were defined as credit cards and other consumer loans.

scenario. The main difference is higher pre-provision revenue driven by higher net interest income due to higher interest rates. In the publicly available results, the authorities did not indicate any impact of higher interest rates on loan delinquency. However, AOCI is three times larger than in the severely adverse scenario due to higher interest rates.

87. In aggregate, the CET1 projections in the DFAST and IMF top-down approach are similar (Figure 7). The minimum CET1 ratio in the benchmark IMF stress test is higher than in the DFAST, mainly reflecting less conservative loan dynamics and lower dividend distributions for firms constrained by the hurdle rate. However, when DFAST assumptions on loan supply, dividend distribution and operational RWAs were introduced in the IMF stress test the CET1 ratio in the benchmark case came down close to the DFAST CET1 ratio.

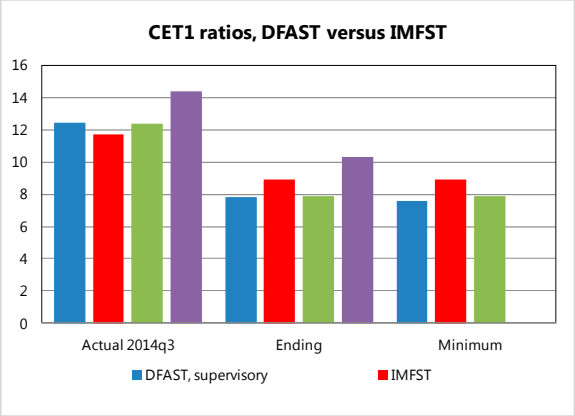
88. However, while the aggregate capital ratio may be similar, RWAs in DFAST were higher than in IMF stress tests. Total RWAs in DFAST were 6 percent higher than in the IMF benchmarks case (again reflecting the difference in credit dynamics that outweigh the addition of the operational RWAs to the IMF model) but also 4 percent higher than in the IMF stress test with the DFAST assumptions. If the DFAST estimates of the 2015 standardized RWAs increase for individual BHCs were applied in the IMF stress test the total RWAs would be very similar.

89. Correspondingly, the aggregated capital level in the DFAST was higher than in IMF's stress test. Although it was not possible to decompose the underlying factors driving this result based on publicly available information, this difference could be due to a number of reasons. First net income losses could have been smaller in DFAST. However, this was not the case, and in fact net income losses in the two stress tests were very similar due to the fact that projected provisions were almost the same and that the sum of pre-provision revenue and trading, counterparty and other losses was very similar to pre-provision revenue in the IMF stress test. Therefore, one or a combination of the following factors could have led to a higher estimate of capital in the DFAST: (i) taxes; (ii) deductions from CET1; (iii) dividends; (iv) extra-ordinary items; (v) change in valuation of allowances. Deductions and dividends were presumably the same in both stress tests in the case where IMF stress test took DFAST assumptions. However, since the details of these other factors were not part of the published results, an accounting of which of these led to the higher aggregate capital estimate could not be ascertained.

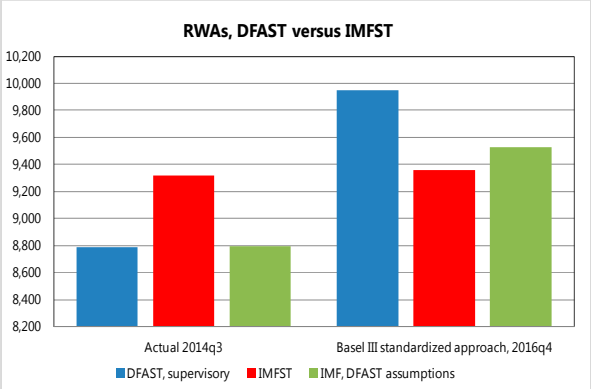
90. Moreover, bank-specific capital ratios differed significantly between the two exercises. About one third of BHCs in the DFAST have either higher or lower CET1 ratio by 2.5 percentage points. For a few large BHCs IMF estimates of CET1 ratios were higher due to high trading and counterparty default losses in the DFAST for these BHCs. For the rest of the BHCs, IMF estimates of net income losses were mainly higher, including for the two BHCs that would fall below the capital hurdle rates. This may be due to the modeling approach of the IMF stress testing framework, which was different from the DFAST due to granularity of the data.

Figure 7. DFA vs. IMF Stress Test Results

CET1 ratios (in percent)



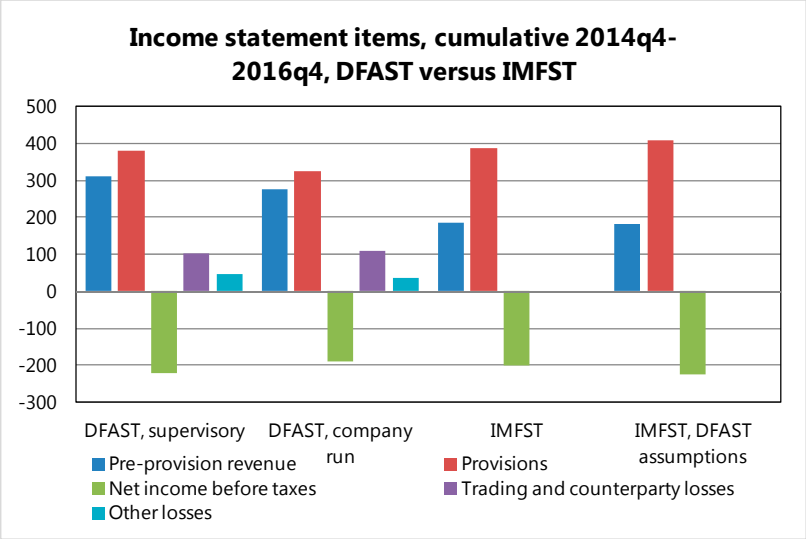
RWAs (in billion USD)



Note: CET1 ratios are defined as total CET1 over total RWAs.

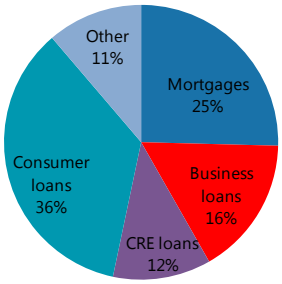
(sum over all 31 BHCs)

Income statement items

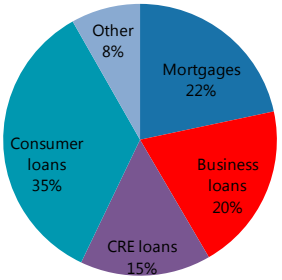


Structure of loan losses

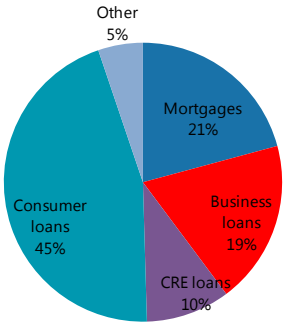
Structure of loan losses, IMFST



Structure of loan losses, supervisory DFAST



Structure of loan losses, company-run DFAST



Source: IMF Staff calculations.

B. Company-run DFAST for 31 BHCs

91. Three bottom-up stress tests were reviewed by the agencies: one by the FRB[63] one by the OCC and one by the FDIC. All the tests relied on banking companies' internal consolidated data to assess solvency of individual companies under different macroeconomic scenarios through

[63] The Fed's bottom up stress test described here is the DFA company-run stress test which is different from the company-run stress test in the FRB's Comprehensive Capital Assessment and Review (CCAR) in terms of capital actions and the scope. The DFA company-run stress test includes BHCs with total assets larger than $10 billion. The Federal Reserve's annual CCAR is an assessment of the capital adequacy of U.S. BHCs with total consolidated assets of $50 billion or more and of the practices these companies use to manage their capital. CCAR is a broad supervisory program that includes bottom-up stress testing but also assesses BHC's own practices for determining capital needs, including their practices around risk measurement and management, capital planning as well as internal controls and governance around these practices.

changes in net income and risk-weighted assets. The cut-off date of both tests of the data was September 2014.[64]

92. The DFA company run stress test covered BHCs with consolidated assets of $10 billion or more, which account for about 90 percent of total BHC assets. OCC's stress tests covered national banks and federal savings association with total consolidated assets over $10 billion. FDIC's stress tests covered FDIC-insured state banks that are not members of the Federal Reserve System and FDIC-insured state-charted savings associations with total consolidated assets of more than $10 billion. Instructions to companies, together with scenarios, were issued on October 23, 2014.

93. This note focuses on the results of the company run DFAST for 31 BHCs. Company-run stress testing results were reported to the primary supervisor on January 6, 2015 for companies with assets size of more than $50 billion and on March 31, 2015 for companies with assets size of more than $10 billion but less than $50 billion. While the results were not published by companies' supervisors, banking organization with assets of $50 billion or more, including 31 BHCs included in the supervisory DFAST, disclosed a summary of the results of the bottom-up stress test, under the severely adverse scenario in March 2015. Other companies will be required to publish the bottom-up stress testing results in the period from June 15 to June 30. To ensure comparability with the IMF top-down stress test and the supervisory DFAST, and given the appropriate coverage of the top-down tests and the timing of the FSAP (the second mission took place during the last week of February and the week of March), only the results of the DFA bottom up stress test for largest BHCs (with total assets of $50 billion and more) are presented in this note.

94. The capital definition applied in the stress tests corresponded to that required by local regulation, i.e., Basel III[65] (subject to phase-in) for advanced approaches BHCs and non-advanced approaches BHCs (from January 1, 2015) and Basel I for non-advanced approached BHC for the first quarter of the stress test horizon (last quarter of 2014).[66] In order to assess the potential impact of negative shocks on the capital requirement metrics over the stress horizon, companies were required to assume consistency with the Basel III transition schedule. The stress tests incorporated the transition arrangements and minimum capital requirements from the revised regulatory capital framework implementing the Basel III capital reforms from January 2014 and Basel I capital standards for non-advanced banking organization applied for 2014 only. Starting in 2015, the revised capital framework introduced a new standardized approach for risk weighting assets, which replaced the calculation of risk weights using the general risk-based capital approach.

[64] The annual stress testing cycle will be shifted by 90 days beginning with 2016 stress testing cycle. For example, the 2016 cycle will begin on January 1, 2016 instead of October 1, 2015.

[65] Basel III capital standards have been implemented by the OCC, FDIC and the FRB in January 1, 2014 for advanced approaches banking organizations. The standards were implemented on January 1, 2015 for all other banking organizations. The revised capital rules apply to national banks, state member banks, Federal savings associations, and top-tier savings and loan holding companies and top-tier bank holding companies domiciled in the U.S. not subject to the Boards' Small Bank Holding Company Policy Statement (with assets less than $500 million).

[66] RWAs under Basel I were calculated using the general risk-based capital approach (12 CFR 225, Appendix A and E).

95. The results of the company run stress test were disclosed by BHCs in the supervisory DFAST format. As in the supervisory DFAST, detailed information on capital, RWAs and income statement items were not publicly available. While capital ratios and income statement items were published in the same format as in the supervisory DFAST for all BHCs, six BHCs did not publish their RWAs which precluded the analysis of the results in the aggregate for the 31 BHCs.

96. On average, the individual results of the company run test were more optimistic than the results of the supervisory DFAST or the IMF stress test. The tests suggest that BHCs are resilient to shocks for the severely adverse scenario. All BHCs stay above the regulatory minima, even if the IMF hurdle rates were used. Over the nine quarter of the stress testing horizon the un-weighted system-wide average CET1 would fall from 12.9 percent to 9.4 percent (its minimum). The average CET1 ratio in the company run stress test is 90bps higher than in the supervisory DFAST and 175bps higher than in the IMF stress test. Higher CET1 ratios are both due to lower increase in RWAs, for the BHCs that reported their projection of RWAs, as well as lower net income losses that were projected to be -$190 billion (compared to -$222 billion in the supervisory DFAST and -$224 billion in the IMF stress test).

97. The differences in the net income losses were mainly driven by loan losses ($250 billion). While trading and counterparty losses ($108 billion) were almost the same as in the supervisory DFAST, projected loan losses were much lower by the BHCs than by the FRB or the IMF. Moreover, the structure of loan losses was different in the company run stress test than in the supervisory DFAST or the IMF stress test. For example, losses on consumer loans represent 45 percent of projected loan losses in the company run stress test, compared to 35 percent in the supervisory DFAST or the IMF stress test (Figure 7).

98. While the correlation between BHC-specific capital ratios for the company run and the supervisory stress test is high,[67] some BHCs reported significantly higher CET1 ratios. Comparing to the supervisory DFAST results, in the company run DFAST five BHCs have higher CET1 ratio by 2.5 percentage points. This is due to lower losses and RWAs projected by the BHCs. Many BHCs argue that the differences in projected net income statement items and RWAs may be due different modeling approaches employed by the BHCs.

IMF STAFF'S LIQUIDITY RISK ANALYSIS FOR BHCS

99. A liquidity risk analysis was done by the IMF team in order to assess the resilience of the banking sector with respect to sudden, sizable withdrawals of funding. The analysis was done as of 2014Q3 on a bank-by-bank basis and included the same BHCs as in the solvency stress test.

[67] The correlation between CET1 ratios in the company-run stress test and in the supervisory stress test is 0.80. The correlation between CET1 ratios in the company-run stress test and in the IMF stress test is 0.47 and the correlation between CET1 ratios in the supervisory stress test and in the IMF stress test is 0.49.

100. Due to data constraints, the LCR or the NSFR was not possible to calculate.[68] The liquidity metric calculated by the IMF team was defined and calculated based on publicly available data reported in FR Y-9C report (Schedules HC, HC-B, HC-D, HC-E, HC-L and HC-M).

A. Liquidity Metric

101. The liquidity metric measured whether BHCs have adequate levels of liquid assets that can be converted into cash to meet their liquidity needs. The liquidity metric was defined as the ratio between the stocks of liquid assets to the total cash outflow. While the items that were included in the numerator and denominator of the metric were informed by the LCR definitions used in BCBS (2013) (Table 13, 14) there was no attempt to replicate the LCR calculation based on publicly available data.[69] Haircuts were taken from the LCR and run-off rates were calibrated based on the 2008/2009 episode.[70] Two stress horizons were assumed over which the withdrawal of funding took place: 1 quarter and 3 quarters. In the sensitivity analysis the run-off rates were calibrated based on the LCR.

Table 13. Liquid Assets

	HAIRCUT
Level 1 assets	
Cash and balances due from depository institutions	0
U.S. Treasury securities	0
Level 2 assets	
Level 2A assets	
U.S. government agency obligations	15
MBSs (guaranteed by GNMA, issued by FNMA, FHLMC, issued or guaranteed by U.S. government agencies or sponsored agencies)	15
Level 2B assets	
Other domestic debt securities	50
Other foreign debt securities	
Investments in mutual funds and other equity securities	

Source: IMF Staff

[68] Banks will start reporting their LCRs by the end of 2015.

[69] High quality liquid assets in the U.S. final rule on the LCR does not include securities issued or guaranteed by PSEs (e.g., state, local authority or other governmental subdivision below the sovereign level) such as municipal securities or RMBSs. Moreover, claims issued or guaranteed by a U.S. GSE are not included in level 1 liquid assets and corporate debt securities are not included in Level 2A assets.

[70] The peak was identified for each outflow item in the period 2008-2009. Each outflow item is a sum of the corresponding outflow item across 31 BHCs. The run-off rate is then defined as the percentage difference between the value of a given outflow items at its peak and its value next quarter (1q stress horizon) or three quarters from the peak (3q stress horizon).

Table 14. Outflow Items

	HIST. RUN-OFF RATE, 1q	HIST. RUN-OFF RATE, 3q	LCR RUN-OFF RATE
Deposits			
Time deposits of less than $100,000	0	15	3
Interest bearing demand deposits, NOW, ATS and other transaction accounts	3	0	3
Time deposits of $100,000 or more	8	21	5
Money market deposits accounts and other savings accounts	0	0	10
Noninterest bearing balances	12	8	10
Deposits in foreign offices	4	15	5
Unsecured wholesale funding			
Unsecured borrowing	4	11	100
Subordinated notes and debentures	4	4	100
Secured wholesale funding			
Securities sold under agreement to repurchase	0	0	15
Secured borrowing	13	22	50
Liabilities for short position	1	35	100
Currently undrawn committed credit and liquidity facilities			
Revolving, open-end loans secured by 1-4 family residential properties	5	13	5
Unused consumer credit card lines	1	12	5
Other unused credit card lines	1	12	5
Commitments to fund CRE, construction and lan development loans secured by RE	6	14	10
Commitments to fund CRE, construction and lan development loans not secured by RE	8	27	10
Securities underwriting	44	70	10
Commercial and industrial loans	2	5	10
Loans to financial institutions	2	5	40
All other unused commitments	2	5	100
Other contingent funding liabilities (such as guarantees, letters of credit, revocable credit and liquidity facilities, etc)			
Financial standby letters of credit	2	4	10
Performace standby letter of credit	2	18	10
Commercial and similar letters of credit	5	26	10

Source: IMF Staff

B. Results

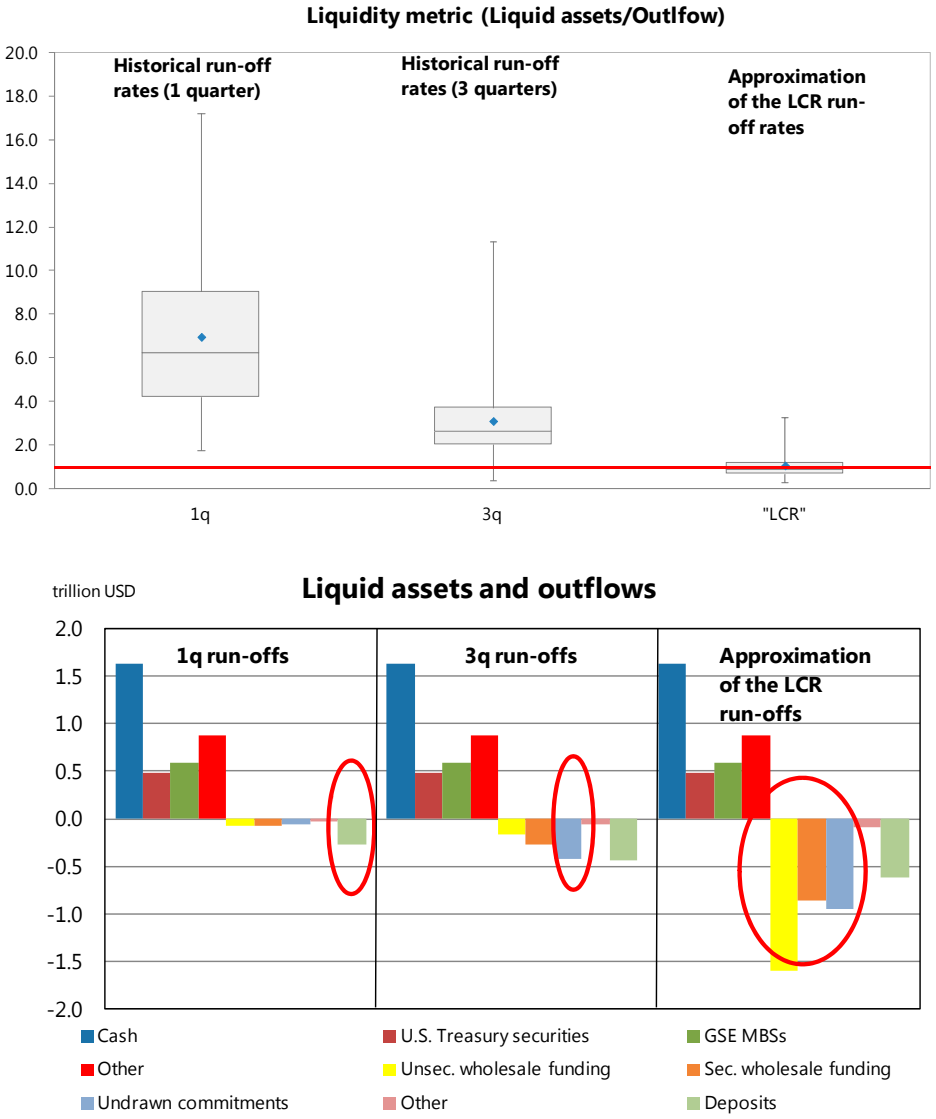
102. The results of the analysis give some comfort that the system is able to meet liquidity requirements, but there are pockets of vulnerability. The analysis suggests that most, but not all, BHCs have enough liquid assets to meet a liquidity shock similar to 2008/2009 event (Figure 8).[71] Several BHCs would face liquidity pressures due to deposit outflows in the short run and large unused commitments over a longer stress horizon. If faced with a much larger shock, as characterized by the LCR run-off rates, liquid assets for many BHCs would not be sufficient to meet liquidity needs due to large withdrawal of wholesale funding. Wholesale funding plays an important role in this case since the run-off rate on wholesale funding is much larger than what happened in 2008/2009.

[71] The Fed's estimates indicate that the majority of the largest U.S. banks would meet the LCR.

103. While the liquidity metric offers some insights into the liquidity risks, the results come with many caveats. While ideally liquid assets should include unencumbered liquid assets only, the liquidity metric here includes both types of assets which will inflate liquid assets.[72] Also, the liquidity metric does not include pledged assets to BHCs which deflates the liquid assets measure. Moreover, inflows were not considered as part of liquidity analysis which would make the liquidity metric smaller than what it would otherwise be. Outflows on derivatives contract were not considered. Due to unavailability of granular data, the actual run-off rates included in the sensitivity analysis had far smaller variation than those in the LCR. Finally, current regulatory report lack important elements to run an accurate liquidity stress test such as liability tenor information, inflows resulting from maturing transactions and relevant contractual terms embedded in derivatives contracts.

[72] Publicly available data do not allow differentiating between encumbered and unencumbered assets.

Figure 8. Liquidity Metric, Historical Run-Off Rates, and Approximation of LCR Run-Off Rates



Note: The whisker boxes display the distribution of the liquidity metric, calculated using the IMF methodology, for 31 BHCs in terms of distribution's moments: the bottom and top of the whisker box are the first and third quartiles, the band inside the box is the second quartile (median), the diamonds represent un-weighted average of liquidity metrics for 31 BHCs, the lower and the upper whisker represent the minimum and the maximum liquidity metric, respectively.

Source: IMF Staff calculations.

IMF STAFF'S SOLVENCY TESTS FOR INSURANCE

104. This section reports on the top-down solvency stress tests for insurance companies performed by the IMF FSAP team. In addition, it also includes a summary of a top-down stress test performed by the National Association of Insurance Commissioners (NAIC) for this FSAP.

A. Scope of the Test

105. The scope of the exercise was broad in terms of risk categories included and methodological approaches. The stress test included a sample of 44 insurance groups, of which 22 are predominantly active in the life insurance business, 15 in property & casualty (P&C) business, five in health insurance, and two in credit and mortgage insurance. All of the groups in the sample are publicly listed. The stress test included the three groups designated both as global systemically important insurers by the Financial Stability Board (FSB) and as systemically important by the Financial Stability Oversight Council (FSOC). Overall, the sample represents 40 percent of the domestic insurance sector in terms of gross written premiums. The separate top-down stress test performed by the NAIC, which also informed the IMF's sensitivity analyses, covered all U.S. life and P&C insurers filing with the NAIC.

106. The stress test used publicly available, consolidated data of insurance groups from regulatory returns provided by SNL Financial and Bloomberg. Further sector-wide data was provided by the NAIC to enhance the granularity of the exercise. The separate stress test performed by the NAIC used legal entity data filed with the NAIC, including both publically available information as well NAIC risk-based capital data filed exclusively with the NAIC and state insurance regulators. The risk-based capital data was only made available to the IMF in aggregate format and not on an individual company basis.

B. Scenario

107. The insurance top down stress test was built on the DFA stress test specifications. Given the nature of insurance business and its balance sheet structure, the main focus of the stress test was on investment assets and, therefore, the market risk parameters of the DFAST. The market risk stresses (Table 15) included shocks to bond holdings (sovereigns, municipals, and corporates), securitizations, equity, property and other investments (such as hedge funds and private equity). In addition, like in the severely adverse scenario of the DFAST, lower swap rates were assumed, in a range of minus 21 to minus 143 basi–s points for maturities of one year and 30 years, respectively. Broadly speaking, the market risk parameters reflect a severe market distress similar to the situation observed at the height of the financial crisis in 2008–09. All stresses were assumed to occur instantaneously.

Table 15. Market Risk Parameters

Market shocks	Change (bp)	Market value change (%)
Bond spreads		
U.S. Government	58,4	
Other Gov - NAIC 1	56,8	
Other Gov - NAIC 2	190,9	
Other Gov - NAIC 3	352,1	
Other Gov - NAIC 4	377,0	
Other Gov - NAIC 5	1.661,0	
Other Gov - NAIC 6	1.661,0	
U.S. Municipals - NAIC 1	66,0	
U.S. Municipals - NAIC 2	372,0	
U.S. Municipals - NAIC 3	429,0	
Corp - NAIC 1	248,1	
Corp - NAIC 2	640,3	
Corp - NAIC 3	985,3	
Corp - NAIC 4	922,3	
Corp - NAIC 5	1.878,0	
Corp - NAIC 6	1.878,0	
RMBS		-51,3%
CMBS		-50,3%
Other Securitizations		-28,7%
Mortgage loans		-12,2%
Equity interest		-28,9%
Property (CRE)		-28,3%
Cash		0,0%
Other investments		-28,9%

Changes in USD swap/discount curve	Change (bp)
1M	-12,6
3M	-11,3
6M	-14,9
9M	-17,1
1Y	-20,9
2Y	-47,0
3Y	-69,8
5Y	-94,0
7Y	-108,5
10Y	-116,4
15Y	-125,8
20Y	-134,2
30Y	-142,6

Source: IMF Staff assumptions based on DFAST.

108. The lack of detailed data on the investments of insurance undertakings made it necessary for the FSAP team to simplify some of the stresses provided in the DFAST, or to re-arrange some risk factors. As an example, the equity shock was not calculated on a per-country basis, but an overall weighted shock was generated based on the geographical breakdown of the equity exposures of the U.S. insurance sector. In a similar vein, the shock for non-U.S. sovereign bonds was derived, split into the rating categories defined by the NAIC.[73] For the property shock, it was assumed that the price developments in the commercial real estate sector as defined in the DFAST for the twelve quarters from 2014-Q4 until 2017-Q4 would occur within just one period.

[73] The NAIC defines six categories of credit quality. They correspond to the rating categories used by Standard&Poor's as follows: NAIC 1: AAA – A; NAIC 2: BBB; NAIC 3: BB; NAIC 4: B; NAIC 5: CCC; NAIC 6: CC or lower, and defaulted.

C. Valuation and Capital Standard

109. An important point of context for the stress tests is that statutory accounting of U.S. insurers is based on U.S. GAAP, which in some instances differs from a "fully market-consistent" approach to the valuation of assets and liabilities. Under statutory accounting, the liabilities of P&C insurers are generally not discounted which adds a layer of conservatism. Also under statutory accounting, life insurance liabilities are discounted with a rate that is set at the time when the policy is sold to the policyholder or with a discount rate based on the expected return of assets associated with the insurance liabilities. The NAIC calculated that the discount rate on all life insurance policies averaged approximately 4 percent in 2013, which is above current market rates.[74] Under statutory accounting, amortized cost is the predominant accounting regime for fixed income assets,[75] which means that neither unrealized gains nor losses are recognized. For the stress test, this results in a significant difference in the impact of a shock to the risk-free interest rate. In a truly economic balance sheet with a fully market-consistent valuation of both assets and liabilities lower interest, as specified in the scenario, mean that the liabilities of a life insurer increase more than its assets, given a structural mismatch of assets and liabilities that is very common in that type of business. While the duration mismatch is usually smaller for non-life insurers, the same mechanics apply. State insurance regulation requires that companies perform an asset adequacy analysis at least annually to measure the structural mismatch of assets and liabilities under a range of different interest rate scenarios.

110. Under statutory accounting, also the impairment rules for life insurers differ from a fully market-consistent regime. Investment assets are impaired only when the fair value loss is deemed to be other than temporary. Once impaired, a bond cannot be written back up to its original fair value after recovery.

111. In the absence of a group capital requirement for insurers, the hurdle rate for the IMF's top-down stress test was set, generously, as the complete extinction of shareholder equity. This means that the capital deemed to cover unexpected losses and serving as "the first line of defense" would no longer be in place. Groups with negative shareholder equity after stress clearly failed the stress test. However, this perspective holds true only in a full fair-value regime. With negative shareholder equity, assets are smaller than liabilities. While such a non-coverage of liabilities might potentially cause policyholders to surrender their life insurance policies (a "run" situation), such a behavior is partly disincentivized by surrender penalties, loss of insurability, and the federal income tax treatment of life insurance. Further, a company's insurance book can be run off in

[74] The average net portfolio yield for life insurance companies was 5.11 percent in 2013.

[75] The actual treatment depends on the credit quality: For life insurers, fixed income assets in NAIC credit quality buckets 1 to 5 are valued at amortized costs, and so are, for P&C insurers, assets in buckets 1 and 2. For the remaining credit quality buckets (6 in life and 3 to 6 in P&C) the lower value of amortized cost and market value is used.

a relatively ordered way, because of the powers the state insurance regulator has in a troubled company context, thereby widely limiting contagion effects.

D. An Overview of Insurance Companies Soundness[76]

112. Balance sheet and asset quality. The aggregated balance sheet of the 44 insurance groups in the stress testing sample increased from 2009 to 2013 by 25 percent to $4.5 trillion. The largest group within this sample consists of life insurers, with aggregated assets of $3.1 trillion. Non-life insurers and health insurers complete the sample with aggregated assets of $1.1 trillion and $0.3 trillion, respectively. The share of the non-life sector fell, owing to the continuing restructuring of AIG, which divested parts of its business in 2010 and 2011. In the aggregate, the ratio of shareholder equity to balance sheet assets was 8.3 percent for life insurers in 2014, and was 22.9 percent and 33.1 for non-life insurers and health insurers, respectively. Non-life insurers hold higher amounts of shares and also shorter durations in their bond portfolio than life insurers. Health insurers have in comparison the most conservative asset allocation, with relatively high allocations in sovereign bonds.

113. In recent years, there was a tendency among life insurers to invest in longer maturities. In 2014, the median duration reached 7.6 years for the life insurers in the sample (an increase from 7.2 years in 2009). In comparison, median asset durations for non-life companies and health insurers were 5.4 years and 5.2 years, respectively. Also, the median share of non-investment grade bonds in the bond portfolio of life insurers reached 5.4 percent, compared to 4.1 percent for non-life insurers and 4.4 percent for health insurers. The share of non-investment grade bonds among life insurers has been decreasing since 2009, while it has been increasing for non-life, albeit from a lower base.

114. Income statement. In terms of revenues (premiums, capital gains and investment income being the main components), health insurers form the largest group in the stress test sample. Their share reaches 42 percent, mainly coming from recurring premiums. Life and non-life insurers account for 32 percent and 26 percent, respectively. Between 2009 and 2014, revenues of life insurers increased by 36 percent. Non-life insurers increased their revenues by 11 percent and health insurers by 46 percent.

115. Nearly all insurers in the stress test sample reported a positive net income in 2014. Returns on equity were highest in the health sector with a median of 14.0 percent. Non-life insurers reported 11.7 percent and life insurers 8.2 percent. Compared to 2013, the return on equity improved substantially for non-life and health insurers, while declining for life insurers.

116. Life insurers have benefitted from positive capital market developments since 2009 with both stock markets and bond markets improving, but have struggled in the face of lower

[76] This section describes the structural developments of the 43 insurance groups included in the top-down stress test for the period from 2009 to 2014.

interest rates. Investment yields have been declining over the last years as higher-coupon bonds expire and are replaced by lower-yielding new issues. For P&C insurers, super storm "Sandy" in 2011 was the latest major catastrophe event, resulting in a median combined ratio[77] above 100 percent. Since then, the combined ratio has stabilized below 100 percent, with the median in 2014 being 94 percent. Over the last five years, changes of the combined ratio have predominantly been driven by the loss ratio, while operating expenses have been stable on average, around 32 percent.

117. While the implementation of the Affordable Care Act resulted in rising premium income of health insurers, uncertainties remain about the future profitability of policies sold under this program. The IMF staff observed that higher premiums and positive profit margins have benefitted health insurers after the first full year of business under the Affordable Care Act. Already since the enactment of the new system in March 2010, stock prices have significantly outperformed the S&P 500. Nevertheless, risks continue to exist for the health insurance industry, notably administrative risks with regard to regulated prices and legal challenges to subsidies provided to policyholders. Also the medium-term behavior of policyholders is unknown, especially lapse rates could be higher than in other health insurance lines. Finally some uncertainties about future claims exist as the Affordable Care Act has led to a shift in the average risk profile of the policyholder by attracting higher-risk cohorts of customers.

E. Modeling Assumptions

118. Assuming a fully market-consistent valuation impact of the shock, the value of investment assets and ultimately shareholder equity declines substantially.[78] Credit spread increases are multiplied with the duration of the respective asset class, derived from the maturity buckets provided in statutory reporting, also resulting in a lower value of investment assets.

119. Separate accounts have not been included in the stress test as investment losses are generally passed on to policyholders. Such accounts are offered by 17 companies in the sample (with a median share of total reserves of 53 percent amongst those companies offering separate accounts). No breakdown of investments or detail on the guarantees provided in these accounts is available in the consolidated public filings, so it was assumed that the asset allocation matches the group-wide asset allocation and no economic loss remains with the insurance company. The market risk shocks were accordingly applied only to the investment assets held in the general account. This simplifying approach might underestimate the effect of the stress scenario in some cases, especially when an insurance company has issued a guarantee for the separate accounts (or parts of them).

[77] The combined ratio shows the sum of losses and operating expenses divided by premiums (or loss ratio plus expense ratio). Values above 100 indicate losses in underwriting business.

[78] Only the stress impact was assessed based on market value changes. A pre-stress transformation of the insurers' balance sheet from statutory accounting to market valuation was beyond the scope of this top-down exercise.

120. In an economic balance sheet approach, the shock to the risk-free rate needs to be applied to both assets and liabilities. While the duration on the asset side can be approximated based on maturity buckets, no detailed information on the duration of liabilities is available. It was therefore assumed, based on suggestions by market participants, that the duration of liabilities exceeds the duration assets by two years in the case of life insurers, and by one year in the case of non-life and health insurers.

121. The stress test does not take into account any mitigating effect from hedging. Insurance companies usually apply a sophisticated hedging strategy with regard to their interest rates (mainly via swaps and swaptions), and also hedge against declines in the stock market via options and futures. As these hedging activities can vary substantially among companies, it is difficult to estimate the mitigating effect in times of stress. In any case, it is very likely that the stress test gives a maximum impact.

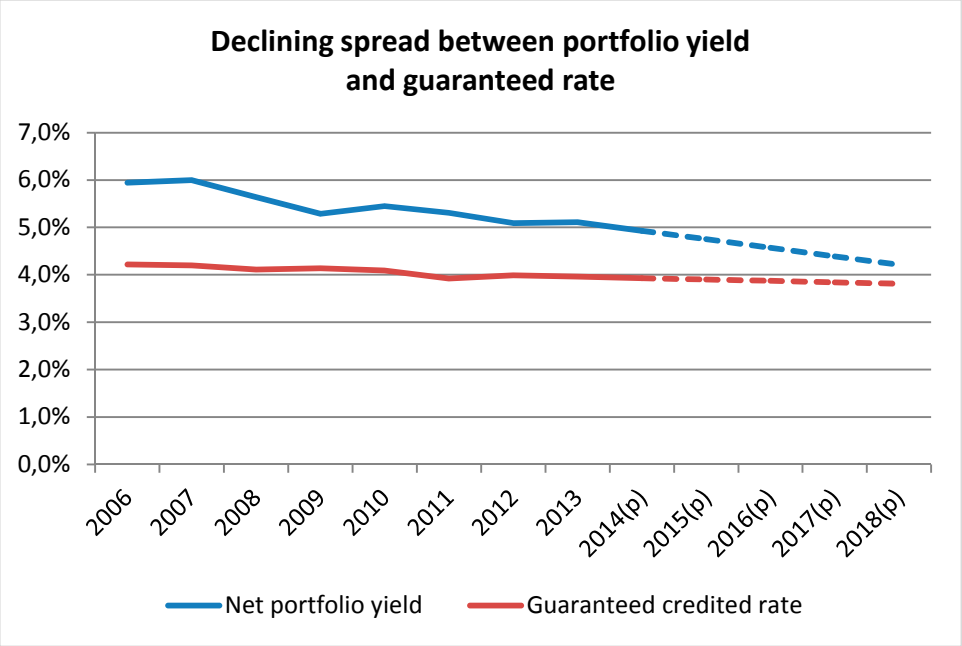
122. For the sensitivity tests, the IMF team built on various approaches developed by the NAIC. This was with regard to modeling the effect of (a) major natural catastrophes, (b) a pandemic, and (c) a prolonged period of low interest rates. The results of these analyses were not added to the outcome of the main stress scenario, although it is possible to assume that the stress scenario occurs at the same time as a major natural catastrophe or a pandemic.

123. The IMF team has specified three types of natural catastrophes, for which the NAIC has provided approximate results. These were based on re-assessing historic events of a similar type and by cross-checking this against newly introduced amendments to RBC filings of companies. The catastrophe events included a hurricane in Florida, similar to but worse than hurricane Andrew in 1992, causing an industry-wide loss of at least $40 billion. As a second event, an earthquake in California, similar to but worse than the Northridge earthquake in 1994 was specified; the earthquake should have a magnitude of at least 7.2 and the insured loss should be greater than $35 bn. Finally, a series of three major tornados should be assumed to occur in the Midwest of the United States, each causing an insured loss of at least $4 billion. Each of these events, which have been modeled to occur independently from each other, would reduce the capital position of exposed P&C insurers.

124. Similarly to catastrophic events which mainly affect the P&C sector, a shock to mortality rates in the form of a pandemic was modeled in the life insurance sector. This mortality shock is calibrated as a pandemic with 1.5 additional deaths per 1,000 which is considered a 1-in-200 year event (Swiss Re 2007). While the increased mortality rate is well below numbers reported for the influenza pandemic in 1918–19, when more than 5 per 1,000 people ceased in the United States, the situation is not directly comparable to today's standards of healthcare and governments' responsiveness. The results for both the catastrophe shock and the pandemic shock do not include potential macroeconomic implications of such an event which in turn could have a further negative effect on capital markets, as recent events like e.g. the SARS outbreak in Hong Kong in 2002–03 have shown.

125. With regard to the prolonged period of low interest rates ("low for long"), the NAIC has provided an analysis that compares the net investment yield of life insurers against the average credited rate. The horizon for this analysis (Figure 9) was from 2014 until 2018. The investment yield was assumed to decline linearly based on the trend observed since 2006.[79] The average credited rate would also decline, as new business would be issued with lower contractual guaranteed interest rates. For example, currently issued annuities contain an interest rate guarantee of 1 percent. The spread between investment yield and credited rate, multiplied with the projected reserves gives the impact on the profitability of the insurer.

Figure 9. Medium-term Projections in a Low Interest Rate Environment, 2006–18



Source: NAIC

F. Results

126. The stress test shows a significant impact on the U.S. insurance sector, especially in the life business (Figure 10). The results for the life insurance companies show a wide dispersion, but 11 out of 22 groups would report negative shareholder equity after stress if a fully market-consistent accounting regime was in place. The effect is larger than what has been observed historically, e.g., in the recent global financial crisis life insurers had the ability to hold their investment assets until maturity without the need to sell them at depressed price—Box 2 provides further analysis on how

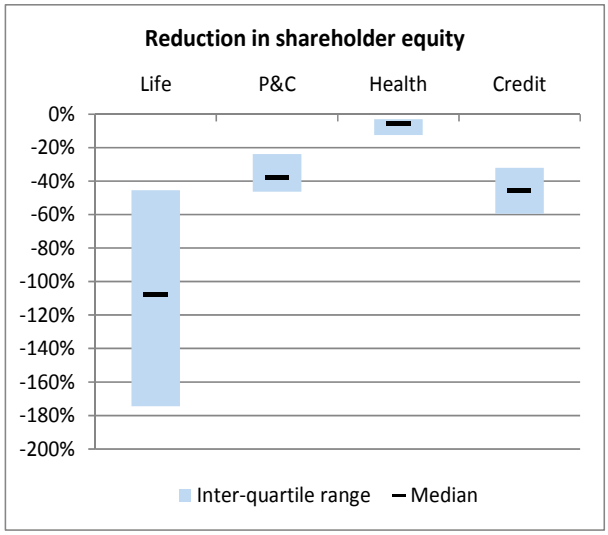
[79] This assumption is a simplification as the downward trend in portfolio yields might flatten out in the future when fixed income instruments with higher coupons have already expired.

stresses unfold under statutory accounting. The other insurance segments are much less affected, given their lower exposure to investment risks. No nonlife or health group would be in distress, suggesting that the respective sectors are in a more robust shape. Overall, the losses in shareholder equity amount to $267 billion, or 45 percent of pre-stress equity. Life insurers contribute to this amount by $187 billion, while $72 billion come from P&C insurers, $6 billion from health insurers, and $2 billion from credit insurers. Out of the total loss, $104 billion is attributed to the distressed companies.

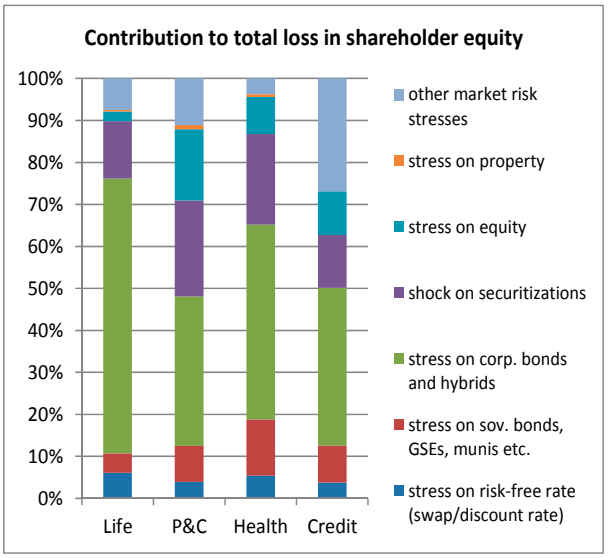
127. The main contribution to the overall loss in shareholder equity, calculated in a fully market-consistent way, comes from the credit spread increase in the corporate bond portfolio. For the full sample, this corporate bond shock (also applied to hybrids) accounts for 62 percent of the overall loss. Further notable contributions come from the shock to sovereign bonds and GSEs, the shock to the securitization portfolio, and the shock to share prices (each with 7 percent). Given their larger holdings in shares, P&C insurers are relatively more affected by the equity market shock, while health insurers would record larger losses stemming from their sovereign bond portfolio. For credit insurers, the full impact of higher credit spreads and higher default rates would likely be higher than the numbers suggest as also their liabilities would be affected.

Figure 10. Top-Down Insurance Stress Test

Life insurance companies most affected in the stress test



Highest contribution from market value losses of corporate bonds



Source: SNL Financial and IMF Staff calculations

128. Among the distressed companies, smaller and medium-sized institutions are in a majority. The aggregated balance sheet assets of the 11 companies amount to around $490 billion (11 percent of the full sample). Their pre-stress shareholder equity declines from $55 billion to a negative $48 billion under stress.

129. A large catastrophic event or a pandemic, seen in isolation, are likely manageable for both the life and the non-life sector (Table 16). The most expensive event would be the Florida hurricane which, modeled as a 1-in-250 year event could cause insured losses of around $80 billion. An earthquake in California with the same expected occurrence frequency could result in a loss of $34 billion, since the vast majority of California earthquake exposure for residential properties is through the California Earthquake Authority. A series of three severe tornados in the Midwest of the United States shows only rather contained effects, substantially below the claims expected in the other two scenarios. A pandemic with 1.5 additional deaths per 1,000 which is considered a 1-in-200 year event (Swiss Re, 2007), could cost the U.S. life insurance industry between $20 and $25 billion. The hurricane and earthquake are estimated net of reinsurance. The pandemic is estimated on a gross basis, not taking into account the mitigating effect of reinsurance and alternative risk transfer, so that only parts of these amounts would ultimately be borne by U.S. insurance sector. However, the results for both the catastrophe shock and the pandemic shock do not include potential macroeconomic implications of such an event which in turn could have a further negative effect on capital markets.

Table 16. Impact of Natural Catastrophes and Pandemics

net claims in USD billion	1-in-100 years	1-in-200 years	1-in-250 years
Florida hurricane	45 - 50		75 - 83
California earthquake	22		34
Pandemic		20 - 25	

Source: NAIC

130. A scenario of prolonged low interest rates poses a slow burning risk which could become a solvency risk for life insurers in a few years. For the period from 2006 to 2013, the industry-wide spread between the net portfolio yield and the guaranteed credited rate declined by 57 basis points. Assuming that interest rates remain at their current levels, the spread could, linearly projected, continue to decline further as the lower rates influence the average guaranteed credited rate at a significantly slower speed than the portfolio yield. The modeling is based on several restrictive behavioral assumptions, especially with regard to the asset allocation, but clearly indicates that the risk of low interest rates requires intense monitoring as it influences the business model of life insurance substantially. While at the moment, the risk only reduces profitability of the companies, potential negative spreads between investment yields and guaranteed rates could result in wide-spread losses ultimately resulting in a weaker capital position of the sector.

Box 1. NAIC Top-Down Stress Test

In parallel to the top down exercise performed by the IMF team, the NAIC has also run a top down stress test based on end-2013 statutory data for the whole U.S. insurance sector. Also the NAIC stress test shows a substantial impact, though less pronounced as no shock is applied to investment grade corporate bonds and sovereign bonds are expected to increase in value (combining the effect of potentially higher credit spreads and offsetting lower risk-free interest rates).

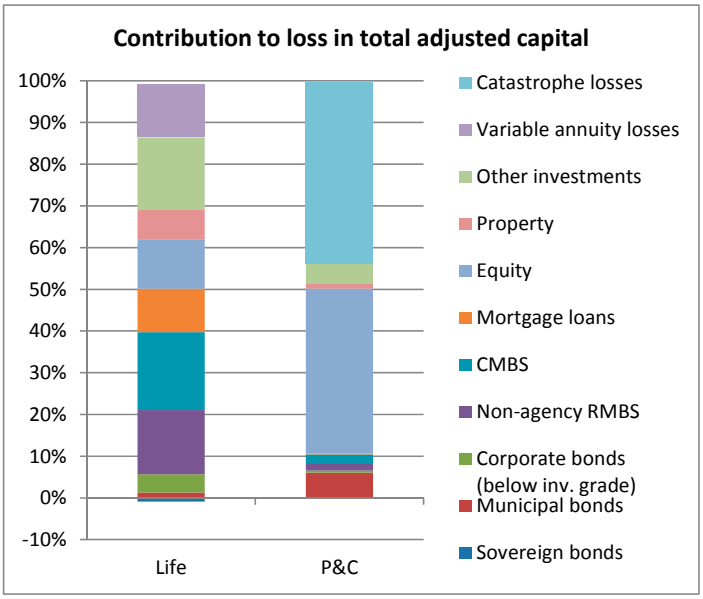
Detail of Stresses	Change in value (in percent)
Bonds	
Sovereign bonds	2,0
Municipal bonds	-5,0
Corporate bonds (below inv. grade)	-5,0
Non-agency RMBS	-28,0
CMBS (Senior)	-5,0
CMBS (Mezzanine)	-25,0
CMBS (Subordinate)	-25,0
Mortgage Loans	-5,0
Equity	
Unaffiliated Common Stock	-40,0
Affiliated Common Stock	-30,0
Preferred Stock	-10,0
Property	-30,0
Other Investments ("Schedule BA")	-30,0
Variable Annuity Losses (10% of maximum guaranteed amount)	
Catastrophe Losses (1-in-250 year event)	

In addition to immediate losses in the general accounts, also guaranteed components of separate accounts were included. In those cases where an insurance company guarantees certain benefits of separate account products, a shock is modeled by applying a factor of 10 percent to the company's maximum possible guaranteed amount that would be diverted from the general account to the separate account.

The exercise further included two natural catastrophes, a Florida hurricane and a California earthquake, each with a 1-in-250 year probability and both occurring at the same time.

Based on statutory accounting, the U.S. insurance industry as a whole shows some robustness although the capital impact is significant. While there are some companies which would fall below the regulatory thresholds, the average decline in total adjusted capital amounts to $166 billion in the life sector (-35 percent) and $267 billion in the P&C sector (-33 percent). Even with stressed capital, both sectors would, on average reach RBC coverage ratios of 659 percent and 447 percent, respectively.

The main contribution to the overall changes comes from the securitization portfolio and other investment assets in the life sector, while for P&C insurers, the equity shock and the catastrophic events have the largest impact.



Source: NAIC

131. The results show the life insurance sector in a very challenging position. Not only could market turbulences cause huge losses in terms of fair value accounting (less so in the current statutory accounting as long as the market stress is not prolonged or substantial), but vulnerabilities persist. The low-yield environment could, if continued, erode the profitability of the sector and ultimately also deteriorate the capital position. Net investment yields would need to remain above 4 percent to ensure profitability. The sector has already reacted and is actively changing its product mix, offering more policies where investment risks are partially or fully passed on to the policyholder.

132. The low interest rate environment is challenging especially for life insurers and caused many companies to change their investment behavior. As insurers search for yield, durations in the bond portfolio have increased since 2009 (Table 17). The share of bonds below investment grade has declined for the life companies in the stress test sample (from 7.5 to 5.4 percent). Over the same period, the share went up significantly for non-life and health insurers, albeit from a low base. Also within the investment grade bond portfolio there was a clear tendency to take on more credit risk by expanding the relative share of BBB-rated assets. Some movement into alternative investments (hedge funds, private equity) has been observed, but this is still of a smaller dimension and rather restricted to larger insurance companies who are expected to have an adequate risk management in place.

Table 17. Changes in Duration and Credit Quality of Bond Portfolio

	Duration 2009	Duration 2014	Share of non-IG in bond portfolio 2009 (in percent)	Share of non-IG in bond portfolio 2013 (in percent)	Share of BBB in IG bond portfolio 2009 (in percent)	Share of BBB in IG bond portfolio 2009 (in percent)
Life	7.2	7.6	7.5	5.4	33.9	37.6
Non-life	5.1	5.4	1.9	4.1	8.7	15.0
Health	4.2	5.2	1.0	4.4	10.1	14.9

Source: SNL Financial and IMF staff calculations
Notes: based on insurance stress test sample

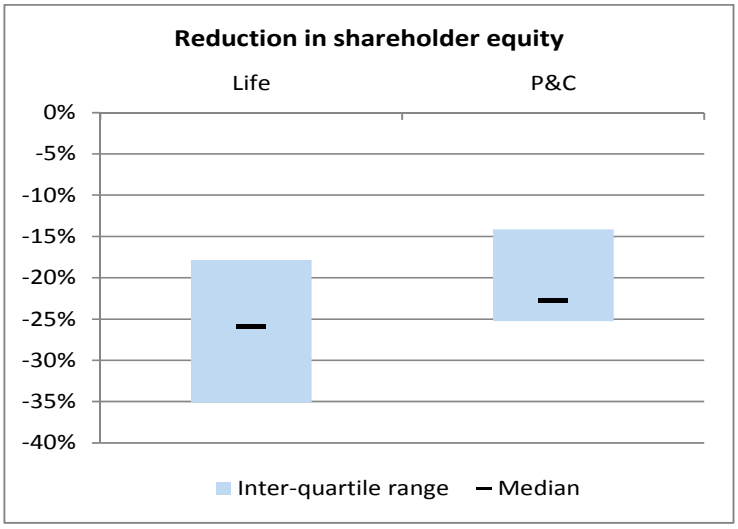
133. While life insurance companies are exposed to the risk of prolonged low interest rates, also a sharp upward shock to interest rates poses a material risk. The market value of the bond portfolio would decline, even more so with the longer durations insurers are holding now. In statutory accounting, however, life insurers would be able to carry many of these assets at amortized cost, unless their decrease in value was determined to be other than temporary. Rising interest rates would likely lead to an increase in policy surrenders when policyholders switch into higher-yielding assets (within and outside the insurance sector), leaving companies with a liquidity drain and potentially some losses for those products where no surrender penalty applies. While the share of companies that fund themselves on the capital market is rather small in the insurance sector, higher interest rates drive up funding costs for those who issue bonds on a regular basis.

134. P&C insurers showed greater robustness in the stress tests. After some years with only few large catastrophes, the capital positions have improved to weather times of stress. However, competition and price pressure have increased with some products, and investment yields have decreased, requiring companies to improve their cost structure and also to remain prudent in their underwriting.

135. Insurance companies are able to mitigate some of the effects of the stress. A range of life insurance products includes profit sharing features between the insurance company and the policyholder which allow the insurer to (partially) pass on investment losses by reducing discretionary benefits. In a risk-based solvency regime, it is also possible for the companies to de-risk their investments in order to reduce their capital requirements, resulting in higher solvency ratios; similarly ceding risks to a reinsurance company could be considered. Finally, dividend policies, both up-stream from subsidiaries to the top (holding company) level and from the top level to shareholders can be actively managed, especially with larger and diversified groups. As the range of management actions is very broad, no general modeling result can be provided based on publicly available data.

Box 2. Additional IMF Stress Test Based on Statutory Accounting

To evaluate the effect of differences in accounting methods, the IMF team complemented its mark-to-market stress test with an additional statutory accounting exercise, based on the same sub-samples of life and P&C insurers[1] and end-2014 data. The difference in the results of both approaches reveals the impact the valuation regime can have on an insurance company's capital position.



The following modeling steps have been taken:

- Mark-to-market impairment, based on the DFAST severely adverse scenario, for holdings in equity, corporate bonds below investment grade, and other investment assets;
- Default losses in the corporate bond and securitizations portfolio (default rates are based on observations from 2008-09[2], with an assumed 50 percent loss given default rate);
- A catastrophic event (for P&C) and a pandemic causing higher mortality rates (for life) which result in net cash outflows of $25 billion in each of the two sectors (outflows are assumed to be distributed among companies according to their respective market share);
- The need to liquidate investment assets to match the cash outflows, realizing losses at distressed market levels; it is assumed that companies would sell U.S. treasury bonds, municipals and GSE issues first.

The aggregated reduction in statutory capital for life and P&C companies under this modeling approach amount to $111 billion, which represents 22 percent of the pre-stress statutory capital. The median loss in the life sample is 26 percent, while for P&C insurer it is 23 percent. One life insurer would be in distress as its statutory capital turns negative, for one other life insurer the reduction amounts to more than 75 percent.

Most of the overall impact can be attributed to the impairment of investments which accounts for 69 percent of the change in statutory capital. The catastrophic (for P&C) or pandemic (for life) event contributes 18 percent, the defaults in the investment grade corporate bond and securitizations portfolio 13 percent and the realized losses in the forced sell-off only contribute marginally (1 percent). The differences between the life and the P&C sector are not very pronounced.

The results of this exercise are broadly in line with those of the NAIC stress test, which was also based on statutory accounting. Some divergence however exists due to a different scenario design; as an example, the NAIC stress test does not include the impact of a pandemic event in the overall results of life insurers.

Notes:
/1 Health and credit insurers have not been included in this exercise.
/2 Default rates are calculated as averages of default rates provided by Fitch, Moody's and Standard&Poor's for the period from mid-2008 to mid-2009 via the Central Repository (CEREP) set up by the European Securities and Markets Authority (ESMA).

IMF STAFF'S LIQUIDITY ANALYSIS OF MUTUAL FUNDS

136. Open-ended mutual funds' investments are exposed to redemption risk.

- Such funds may be more susceptible to runs when their investments are directed into markets that are less liquid. Their liabilities are liquid due to a regulatory obligation to meet investor redemption demand in-cash within 7 days, yet they may possess neither the balance-sheet liquidity capacity nor access to robust-to-severe stress back-up lines of liquidity. This could leave funds with no recourse but to sell assets in the open market, even at a steep discount.

- The rapid expansion of such funds into fixed-income markets has raised concerns about the potential for investor runs on funds to exacerbate asset market stress. The markets for corporate bonds, emerging market debt, bank loans, and municipal bonds are less liquid than equities, U.S. Treasury, and GSE securities. Moreover, there has been a notable decrease in trading liquidity in corporate bonds since the crisis.

137. IMF staff has performed an analysis of liquidity in U.S. mutual funds, and important caveats apply. This was the first time this type of analysis was performed in an FSAP context, and while publicly available data are voluminous they are incomplete in important respects. Moreover, the analytical basis for analyzing the liquidity position of mutual funds is still nascent. The analysis could therefore be only exploratory in nature, but still provides interesting results that help point to possible vulnerabilities and areas where further analysis may be warranted.

138. The analysis was geared to measuring whether markets would be able to absorb severe redemption pressures wherein these funds are forced to liquidate positions. Ideally, an asset pricing model would be deployed to examine the (marginal) impact of redemption spikes on asset prices or (bid-ask) spread measures of market liquidity. Absent such a model, the approach taken in this exercise was to assess whether a standard metric of available trading liquidity, dealer inventory in specific assets markets[80], is sufficient to absorb redemption demand in a tail risk scenario. Dealer inventory was selected as a proxy for trading liquidity because it was believed to provide a useful indication of market appetite for a variety of asset classes.

139. Specifically, a top-down liquidity risk analysis was performed. Close to 9,000 mutual funds representing around 80 percent of the industry were analyzed. The funds were divided into

[80] This metric has been used in many analysis as an indicator of market liquidity, including by OFR (2014), IMF (various 2014 GFSR chapters), BIS (Fender and Lewrick, 2015), and New York Fed (Adrian and others, 2013). Also, the FSOC's 2015 Annual Report (FSOC, 2015) notes that broker-dealers have significantly reduced their inventories of certain fixed income securities, pointing out that "market liquidity may be impaired if broker-dealers are less willing or unable to intermediate supply and demand imbalances." A recent analysis by Goldman Sachs (2015) suggests that changes in the inventory level of corporate bonds at primary dealers are not correlated with mutual fund outflows. However, they also find that, based on the "taper tantrum" experience, dealer inventory and mutual fund outflows are positively correlated which suggests that dealers inventory might be a good metric of market liquidity in the stress period.

69 styles[81] capturing their investment objectives. For each market under consideration (mortgage, corporate, municipal, government bonds), the universe of funds captured by this approach includes both index funds and hybrid funds. Opting for this style-based approach means greater coverage of funds investing in each market of interest, but it also entails a greater aggregation in the markets analyzed. For example, it is possible to stress market liquidity in corporate bonds markets but not separately for investment grade and high yield. The choice of such an approach is justified by the fact that it is important to capture a full universe of funds. The calculations were based on granular data on mutual funds from the Center for Research in Security Prices (CRSP). The cut-off date for the analysis was the third quarter of 2014.

140. The IMF staff compared assets sold by mutual funds hit by a shock to data on dealers' inventory. If dealers' inventory would be smaller than assets sold by mutual funds this would indicate potential liquidity pressure on mutual funds that invest in the assets sold in that particular market. This might also give rise to fire-sale risks on that particular market and might imply that investors in the funds exposed to those markets have to take a haircut on their investment.

141. The shock was defined as a one time, tail event redemption shock. The distribution of net flow rates, including both net inflows and net outflows, by fund style was analyzed. Net flow rates were defined on the monthly basis as a simple average of net flow rates of all mutual funds of the same style over the period 1998-2014Q3. The first percentile of net flow rate distribution was taken as the stress redemption shock. Averaging redemptions across component market segments (such as investment grade and high yield) was a simplifying assumption that may affect the results of the analysis.

142. Once a mutual fund is hit by a redemption shock it would have to sell its assets to meet redemptions. The following two sets of assumptions on redemption induced assets sold were made:

- *Approach 1 ("pro rata"):* Pro-rata selling of assets was assumed i.e. assets were sold to meet the redemptions by making sure that the structure of assets is intact. This assumption is a natural one to adopt for the case of index funds which would be expected to sell assets to meet redemption demand in a way that seeks to keep portfolio weights unchanged to continue minimizing tracking error relative to their benchmark.

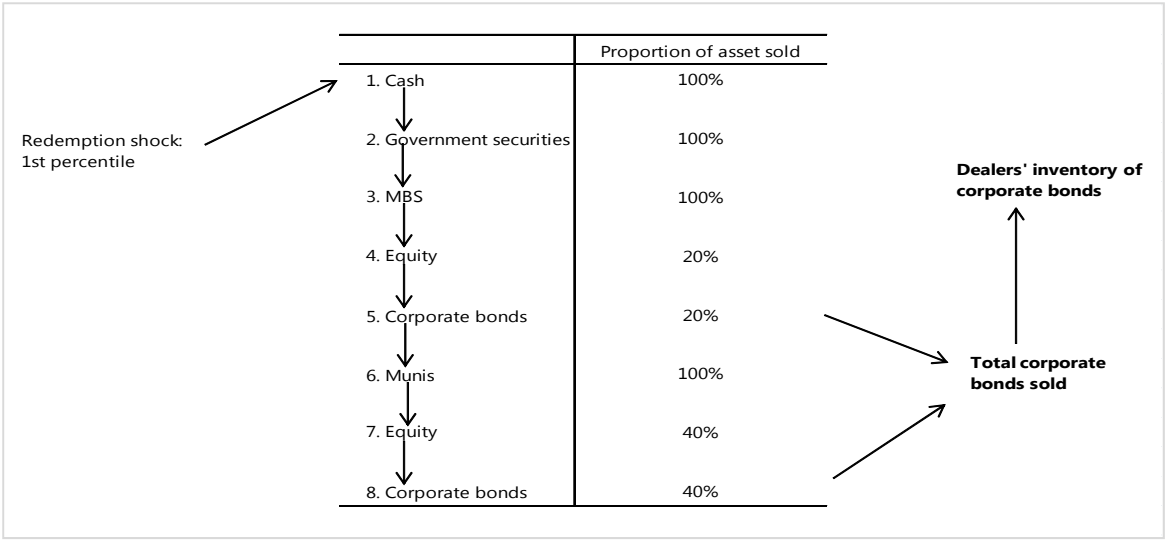
- *Approach 2 ("waterfall"):* Mutual funds were assumed to rank order assets held by their liquidity characteristics, as captured by the LCR haircut hierarchy, selling assets to meet redemptions in descending order of liquidity. Specifically, the assets were assumed to sold in

[81] In the context of this technical note, mutual fund styles, such as equity-based or fixed income-based investment styles, follow a modified version of the CRSP style codes. These modified CRSP style codes consist of up to four characters, with each character position representing a distinct style attribute and an increased level of granularity. Modified CRSP style codes were created by IMF staff in consultation with CRSP, and differ from traditional style codes in that they establish a subset/superset relationship between related styles.

the following order (Figure 11):[82] cash is the first asset to be used to meet redemptions, government securities are second, MBSs are third (assuming most are GSE-backed MBSs), then 20 percent of equity and corporate bonds, then municipal bonds (whole portfolio) and then an additional 40 percent of equity and corporate bonds.

- Under both approaches, realized assets sales due to the tail event shocks were added up across all funds included in the exercise and for each asset market and then compared to dealer inventory, which is was used as a proxy for assessing market makers' (dealers) willingness and/or ability to make markets in, and as an indicator of general market demand for, a given asset class.

Figure 11. Mutual Fund Liquidity Analysis: The Waterfall Approach

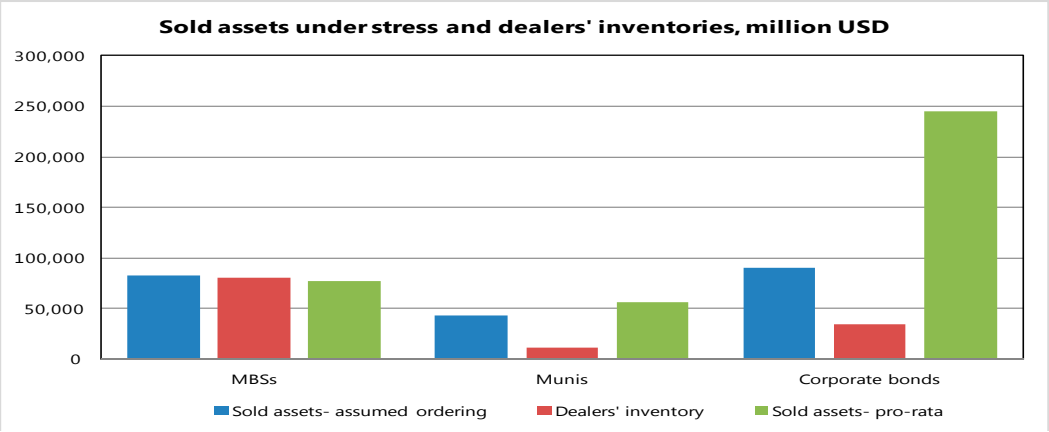


Source: IMF Staff

143. The results of the analysis, under both approaches, suggest that municipal bonds and corporate bonds markets may face significant stress when faced with tail event redemption shocks. The analysis illustrates the danger that funds that invest in corporate and municipal bonds might sell these assets at a fire-sale discount to meet redemptions. Under the same tail event shock, municipal bonds that might be sold to meet the redemptions could be three (in the case of the assumed ordering of assets sold) to four times (in the case of pro-rata asset selling) larger than the dealers' inventory of municipal bonds (Figure 12). Similarly, the analysis shows that the volume of corporate bonds sold under severe stress by mutual funds could be up to seven times larger than what dealers currently hold in inventory.

[82] The assumed ranking of assets sold was based on economic reasoning and expert insights. Nonetheless, it might not apply for funds of different styles. Ideally, the ranking should take into account their mandate and their strategy, which was resolved by the first approach.

Figure 12. Results of the Liquidity Risk Analysis



Note: "Sold assets- pro-rata" represent asset sold by mutual funds hit by a tail event redemption shock that have to sell their assets pro-rata i.e., by making sure that the structure of assets is intact (approach 1).
"Sold assets- assumed ordering" represent asset sold by mutual funds hit by a tail event redemption shock that have to sell their assets in descending order of liquidity (approach 2)
Source: IMF Staff calculations.

144. A number of caveats precluded a more detailed analysis of the liquidity risks in the mutual fund industry. First, not all mutual funds were included in the analysis, and a larger sample would make the assets sold under stress larger, underscoring the vulnerabilities identified. Second, the data used in the analysis may not have been granular enough (both on the mutual funds' asset structure and on the structure of dealers' inventories) to fully capture the liquidity dynamics of a potential asset fire-sale. For example, both domestic and foreign corporate bonds were bundled in the same category of corporate bonds and compared to dealers' inventories of corporate bonds. This prevented the analysis from discriminating among potential differences in the liquidity profiles of the two bonds types.[83]

145. To address the caveats and more closely examine the potential illiquidity of mutual fund assets, IMF staff performed a separate security-level analysis of mutual fund portfolio holdings. This was done by combining portfolio security information from CRSP with security issue(r) information from the CUSIP Global Service's CUSIP Master File and the Mergent Fixed Income Securities Database, and then aggregating security holdings into homogenous asset classes, based upon their perceived liquidity characteristics. Unfortunately, the issuer information from the latter

[83] A separate liquidity risk analysis was performed for MMMFs. The test was geared toward measuring the extent to which MMMFs have enough liquid assets to meet in an orderly manner redemptions given a market shock. A liquidity metric was adopted to assess whether the MMMFs analyzed had adequate levels of liquid assets that could be converted into cash to meet the liquidity demands of a 1 percent probability net outflow (i.e., the 1 percentile of the historical distribution of net flows). In this case, haircuts were applied to liquid assets, in line with the Basel III Liquidity Coverage Ratio, to ensure that an unexpected market event could potentially cause certain previously liquid securities to become illiquid. The results suggest that the MMMFs analyzed would not face significant liquidity risks as their liquid assets were three to five times larger than the liquidity demanded by the tail event redemptions. However, only a small subset of MMFs with detailed asset data was available in the CRSP dataset used in the analysis.

two sources was found to contain a significant domestic equity reporting bias or to only cover a small fraction of the securities present in the CRSP holdings database.[84] Accordingly, the aggregated asset classes were deemed unrepresentative of the broader mutual fund holdings universe, and liquidity assessments using these asset classes as inputs were not pursued further.

146. In the absence of data constraints, the "ideal" liquidity analysis would utilize detailed supervisory data on fund holdings and explicitly take into account individual fund characteristics and market-level liquidity information. This includes information such as investment mandates and trading volumes, when estimating redemption risk and the potential for asset fire sales. For each individual fund, such an analysis would: (i) determine tailored liquidity waterfalls based upon investment mandates, (ii) apply extreme redemption shocks to assess the immediate demand for cash, (iii) use the liquidity waterfall to estimate which, and how much of, each security should be sold to meet redemptions, and (iv) use cumulative information on security bid-ask spreads and trading volumes to estimate what the sales price of each security sold would be. The liquidity analysis would then aggregate the value of the securities sold across funds into granular asset classes, and compare these values to what would have been obtainable under ordinary market conditions in order to determine which particular asset classes may be most prone to fire-sale dynamics.

147. The authorities are encouraged to step up work to assess susceptibility of markets to extreme mutual fund redemptions. The authorities should further clarify the guidance on liquidity risk analysis performed by the industry. It is important that the authorities mobilize the resources necessary to regularly conduct liquidity risk analyses as part of their overall approach to mutual fund industry oversight.

IMF STAFF'S MARKET-PRICE BASED STRESS TESTS

148. This section presents the results of IMF staff's market-price based analysis and stress tests. This exercise is intended to complement the analysis above by taking into account the information about risk that is embodied in market prices, which allows consideration of correlations between institutions and higher frequency and more timely assessments. There are important caveats that must be acknowledged, however. The findings are necessarily sensitive to: methodological issues or choices – such as simplifying assumptions; the use of imperfect proxies; the selection of sample periods; heterogeneity across model, data, and variable definitions; and potential endogeneity.[85] Accordingly, in many cases these findings should be interpreted as informative

[84] The CUSIP master file was found to contain information for 56 percent of the securities with CUSIPs in the CRSP holdings database. Of these observations with available records, about 90 percent were for equities. The Mergent database contains information for only 8 percent of the securities with CUSIPs in the CRSP holdings database. Crosschecks on the CRSP holdings database using two–digit issue CUSIP codes found that the broad breakdown of equity and fixed income securities differed materially from what was observed in the sample of aggregated results.

[85] Where possible, IMF staff made attempts to mitigate methodical issues by adding control variables and by performing robustness checks, however, it was not always possible to completely eliminate their influence. Simplifying assumptions were often used when more complex and realistic processes could not be utilized, and these

(continued)

approximations, as opposed to precise estimates, which primarily highlight the co-behavior of risk factors rather than causal relationships between them. Despite these caveats, the market-price based analysis and stress tests are useful tools for examining the financial stability landscape. For this reason, they have been used extensively in previous work by IMF staff as well as many central banks and others analyzing systemic risk.

149. The section is divided into two complementary parts. First, a broad survey of available systemic risk measures is presented and their historical evolution is examined. Second, a stress testing analysis of the market-implied interaction between default risk and the macroeconomic environment is conducted using the Contingent Claims Analysis (CCA) framework. Both parts use high-frequency, forward-looking market consensus information to "cross-check" the findings of IMF staff's other stress test methodologies. They also extend stress-test coverage to sectors which are not traditionally subject to microprudential oversight, such as non-bank non-insurance financial institutions, and help to compensate for a lack of access to supervisory data.

A. Systemic Risk Dashboard

150. To limit model risk, this technical note adopts a multi-model approach to identifying systemic risk in the United States. There exist numerous definitions of systemic risk, and the methodologies employed to measure such risk are diverse as well. Accordingly, this technical note adopts a multi-faceted approach, called a "systemic risk dashboard", which employs a range of measures in an effort to identify the numerous dimensions in which a threat to financial stability may arise. The dashboard helps to inform the risk-based assessment process and to guard against another important type of risk known as "model risk", which is the excessive reliance on a single modeling framework.[86]

Key Dashboard Findings for the United States

- ***Market-based measures point to a reduction in the systemic risks of banks***. Systemic RISK[87] ("SRISK")—a well-known measure of market-implied capital shortfall for a given bank

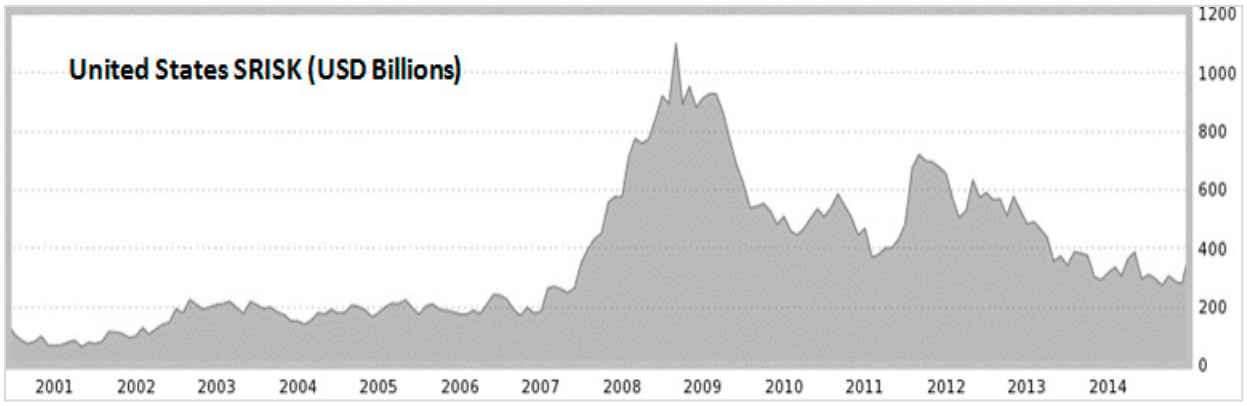
assumptions may not always accurately reflect actual dynamics. Specific factors can often be technically difficult to identify and better proxies may exist than the ones that were used to approximate them. Similarly, the categories used in analyses may have been defined or aggregated in either too broad and or too narrow a manner to unambiguously identify the impact of important effects. Sample periods may not have fully captured the evolution of relevant tail risks, which could potentially influence estimated relationships and limit the comparability of findings across different risk measures. Finally, endogeneity may not have always been fully controlled for, complicating identification in models with jointly estimated variables. Endogeneity can arise either because of reverse causation or because of omitted explanatory variables, and its presence makes it difficult to determine whether findings are truly causal or simply driven by a set of common unidentified factors.

[86] Not all measures presented in the systemic risk dashboard are appropriate for assessing all dimensions of systemic risk. For a fuller discussion of these metrics, including their strengths and weakness, see Blancher and others (2013) and Office of Financial Research Working Paper #1 as well as their references.

[87] Specifically, SRISK is an estimate of the capital that a financial firm would need to raise if a severe financial crisis were to occur. See Acharya and others (2012) for additional details.

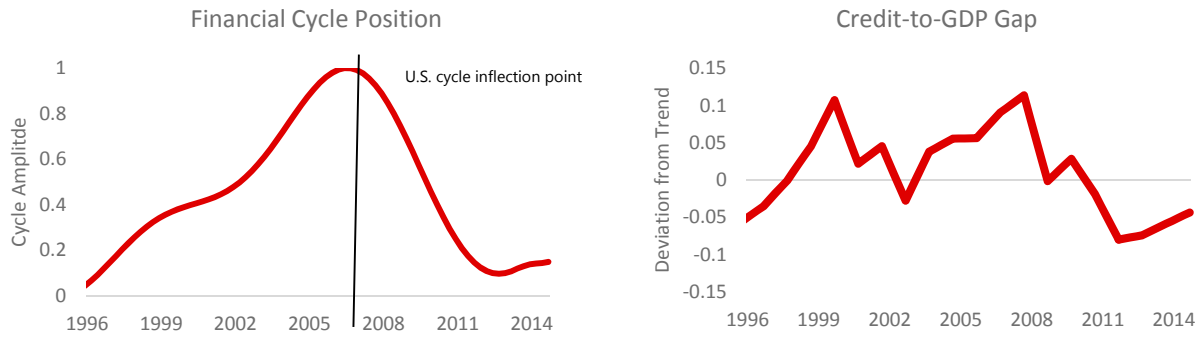
or given banking system—suggests that systemic risk posed by banks has declined towards to its pre-crisis average. SRISK capital shortfalls peaked at approximately one trillion dollars in early 2009 but have now fallen to 300 billion dollars. This level is roughly commensurate with average pre-crisis shortfall estimates and constitutes approximately 2 percent of GDP (Figure 13). One caveat is that SRISK exclusively measures systemic risk in the banking sector. Risks posed by nonbanks are covered in subsequent analysis.

Figure 13. SRISK Market Implied Capital Shortfalls



Source: NYU Stern Volatility Lab, as of end 2014Q

Figure 14. Early Warning Indicators



Source: IMF staff calculations.

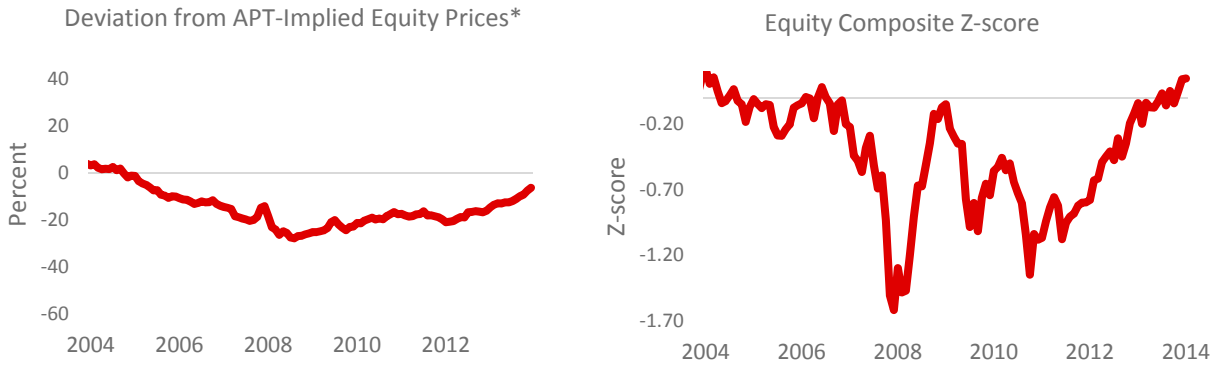
- ***Standard early warning indicators of banking distress are also reassuring***. Both financial cycles[88] and credit-to-GDP gap[89] measures (Figure 13)—widely-used early warning indicators

[88] Financial cycles are computed using the BIS bandpass filter methodology (BIS, 2011; Otker-Robe et al, 2015) and capture the co-movement between credit growth and residential property prices. Empirical evidence finds that

(continued)

of impending domestic financial crises—signal that the United States banking system is relatively healthy from a cyclical perspective. Downward inflections in financial cycles and positive credit-to-GDP gaps often coincide with periods of financial distress.

Figure 15. Equity Price Misalignment Measures



Source: IMF staff calculations.

- ***Equity price indicators suggest that valuations may be stretched relative to fundamentals***. Percentage deviations of observed equity prices from theoretical prices based on Asset Pricing Theory (left) and the Equity Composite Z-score[90] (right) (Figure 14) indicate the degree to which equity prices are misaligned with economic fundamentals. Figure 14 shows that these indicators are either positive or have been trending into positive territory, which suggests that equity price levels may be approaching unsustainably high levels.

- ***Housing price indicators are at normal levels, but need to be closely monitored***. Turning to measures of credit and housing price sustainability (Figure 16), credit-based measures (top) are still well below their pre-crisis levels, indicating that excessive credit growth does not pose an immediate financial stability risk to the United States. However, growth in

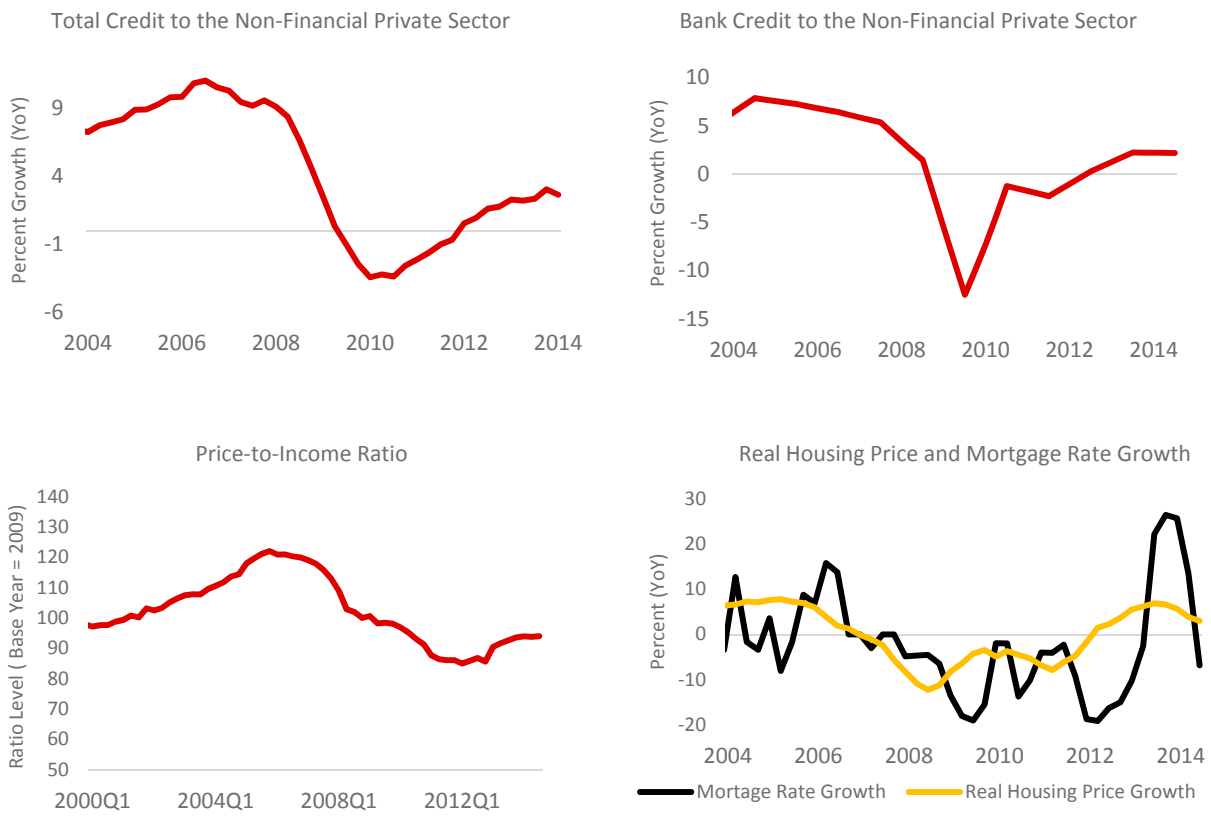
downward inflections in a country's financial cycle can be a predictive sign of an impending domestic financial crisis. For example, the dashed black line shows a downward inflection for the United States in 2007, which suggests the possible onset of a financial crisis in the following years (i.e., 2008-09).

[89] The credit-to-GDP gap is defined according to current Basel Committee on Banking Supervision guidance (BCBS, 2010) as the difference between the credit-to-GDP ratio to its long term trend, calculated using a one-sided HP filter with a smoothing parameter of 400,000. When a country's credit-to-GDP gap shows a positive deviation from trend, this is taken as a signal that domestic credit growth may be excessive and contributing to a credit bubble.

[90] The Equity Composite Z-Score is defined as the arithmetic mean of the deviation of observed equity prices from APT-implied equity prices (Figure 13 left) and other traditional valuation measures such as dividend yields, price-to-book, price-to-earnings, 12-month forward price-earnings, and price-to-cashflow ratios. All component values are normalized into z-scores and aggregated to the country-level prior to averaging. Positive values indicate equity overvaluations.

housing prices (bottom) has fully regained its pre-crisis momentum and needs to be carefully monitored.

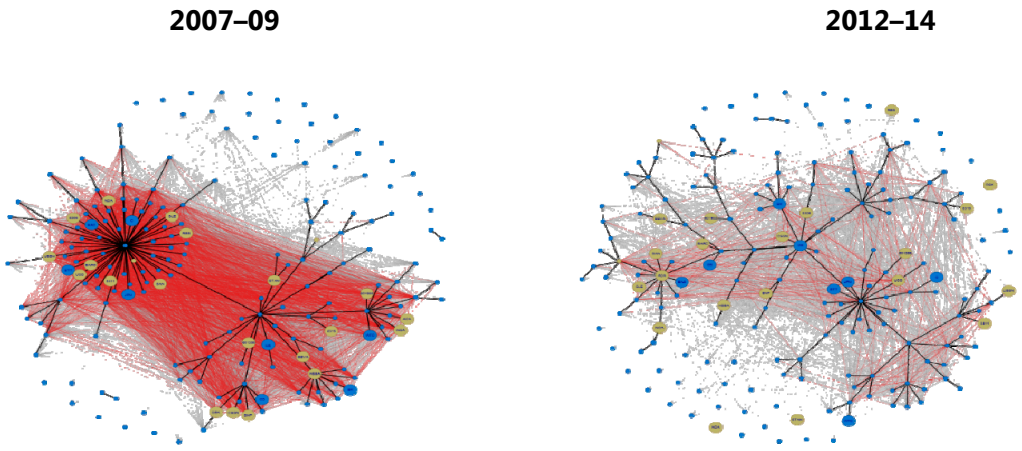
Figure 16. Fundamentals in Housing and Credit



Source: IMF staff calculations.

- ***The potential threat posed to the financial system from credit risk migration has declined significantly since 2007-09, but remains a concern***. An analysis of U.S.- and foreign entity-based credit risk networks (Figure 17) suggests that there has been material decline in the susceptibility of institutions to credit risk migration, as denoted by the decrease of dense, red connections in the current period relative to 2007–09. Nonetheless, the role played by GSIBS in the transfer of credit risk appears to remain important.

Figure 17. Credit Risk Networks



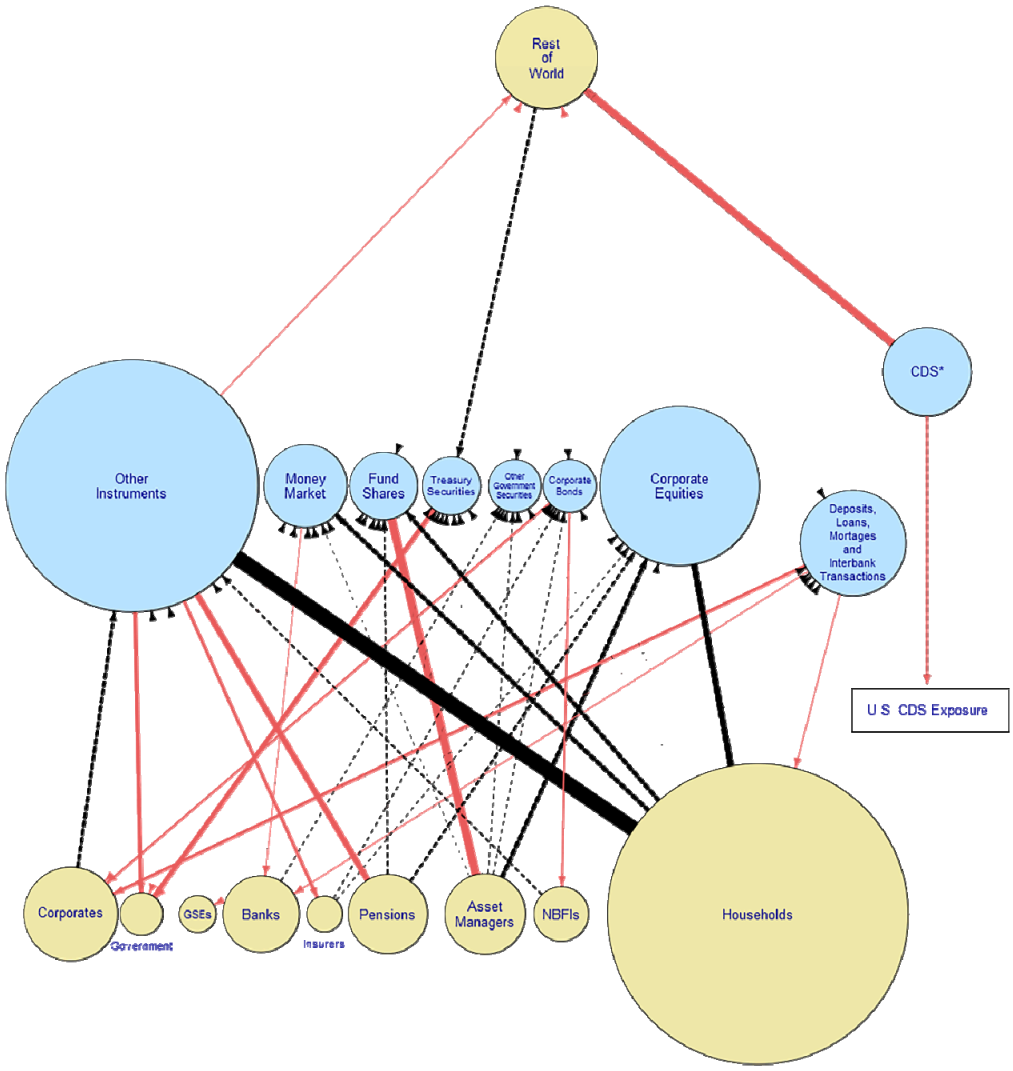
Source: IMF staff calculations.
Note: The credit risk networks shown were created by applying bivariate Granger-Causality tests to time-series of 198 institutions' first-differenced default probabilities. These tests were applied 21 times at differing specifications and the color the connecting lines reflects the robustness of the identified Granger-casual connections. Red connections were found in 95 percent or more of trials, dark gray connections were found in 70 percent or more of trials, and light gray connections were found in at least 50 % of trials. Thick black connections represent membership in the network's minimum spanning tree. Node size represents the GSIB vs non-GSIB (large vs. small) network dimension and node color (blue vs. gold) reflects the domestic vs. foreign dimension. The 21 testing specifications are combinations of three different test significance levels (1%, 5%, and 10%) and seven different lag orders (orders 1 through 7).

- **Individual financial system sectors are exposed to each other, and to the rest of the world, through a common set of financial instruments** (Figure 18).
  - Asset managers, insurers, pensions, and households are sizable net claimants on the corporate equities and corporate bonds issued by other sectors, such non-financial corporations ("corporate") and nonbank financial institutions (NBFIs).
  - Asset managers, insurers, pensions, and households, in addition to banks, also serve as notable net claimants on the government through their holdings of treasury, agency, and municipal debt securities.
  - The largest net claims on fund shares, the primary instrument used by asset managers to raise capital, are attributable to the households and pensions, although banks, insurers, and non-financial corporate also possess net claims on this sector as well.
  - Money market instruments act an important conduit between households, asset managers and banks.
  - Banks, corporates, households, and GSEs have net exposures to all other sectors, and to abroad, via an assortment of deposits, loans, and mortgages.
  - Government and pensions are significantly exposed to households and corporates via pension entitlements.

- On a net basis, the rest of the world is exposed to the U.S. financial system primarily through net claims on money market instruments, corporate equities, and other direct investment. Foreign net claims on the United States take the form of shares in investment funds, government securities, corporate bonds, loans, mortgages, and miscellaneous deposits.

- Publicly available locational data on OTC credit-default-swaps (CDS) shows that both the rest of the world and the aggregate U.S. financial system have sizable outstanding exposures to these instruments. Unfortunately, additional detail on the nature of these credit risk exposures, or other OTC derivatives exposures, cannot be obtained without access to confidential trade information.

Figure 18. Financial Account Net Exposures



Source: FRB; BIS; IMF staff calculations

Note: Yellow nodes denote sectors and blue nodes denote instruments. Node size represents the total value of balance sheet assets held by each sector or cumulatively outstanding for each instrument as of 2014Q3. The directed lines between each node, and the color of these lines, represent the net exposure of a given sector to a given instrument. Black lines denote the net claims of a sector, and red lines denote net liabilities of a given sector, in the form of a given instrument. Line thickness signifies the magnitude of net claims (red lines) and net liabilities (black lines). The thicker (thinner) a line, the larger (smaller) the size of a given net exposure. Net exposures were calculated for each sector-instrument combination by subtracting (netting) liabilities from asset claims.

All lines are directed, but arrowheads may not always appear due to formatting limitations. Black lines without visual arrowheads are always directed from a sector to an instrument. Similarly, arrow-less red lines are always directed from an instrument to a sector. The dashed line effects do not have a semantic significance and are used only as a visual aid.

The instrument "CDS" represents the aggregate, over-the-counter (OTC) credit default swap (CDS) exposure attributable to different domiciles as calculated by official BIS statistics. The box titled "U.S. CDS Exposure" represents the aggregate OTC CDS exposure of U.S. counterparties that cannot to be attributed to specific domestic sectors. Detailed sector and instrument definitions are presented in Appendix Table 7.

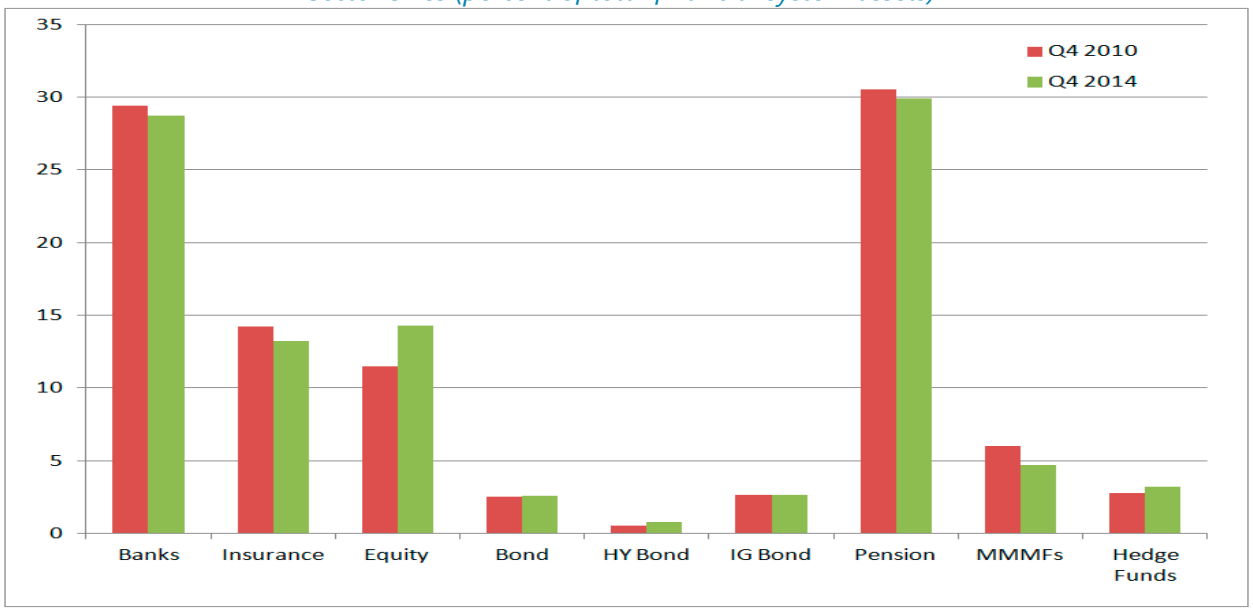
- **Comprehensive measures of systemic risk suggest that nonbanks contribute more to systemic risk than banks.** An important analytical tool in this regard is the Systemic Risk Indicators (SyRIN) framework, which uses distress-based metrics[91] to assess the level of systemic risk present in a given set of financial sectors. SyRIN has been used in earlier studies, for example in the October 2014 *Global Financial Stability Report* (IMF, 2014b).[92] An examination of the U.S. financial system using this framework finds that although systemic risk in the United States appears to be declining towards pre-crisis level, confirming the findings from narrower measures such as SRISK, areas of concern remain. The framework highlights that in terms of asset size, banks account for less than 30 percent of the U.S. financial system, with more than 70 percent accounted for by nonbanks, and these asset shares were broadly unchanged between 2010Q4 and 2014Q4 (Figure 19, top chart). But the SyRIN framework also shows that there are parts of the nonbank sector that contribute to systemic risk more than one could expect based on their size. The marginal contribution to systemic risk (MCSR) of the U.S. high yield and insurance sectors is disproportionately large relative to their share of financial system assets. At the same time, for example, the pension sector's ratio of MCSR to size is approximately 0.6. This means that the pension sector contribution to systemic risk is lower relative to its size, hence this sector appears to diversify risk from the financial system (Figure 19, bottom chart). A longer-term analysis of the ratio of MCSR relative to size suggests that these ratios for High Yield Bond Funds, IG Bond Funds and Hedge Funds have shown a significant increasing trend.

[91] In the SyRIN framework, "distress" is defined as an event whereby the index used to represent returns in a given sector falls to a level which history would suggest should only be observed 1 percent of the time. SyRIN estimates of joint distress incorporate co-movements in market prices. Market prices can reflect consensus views on distressed portfolio reallocations and other indirect effects.

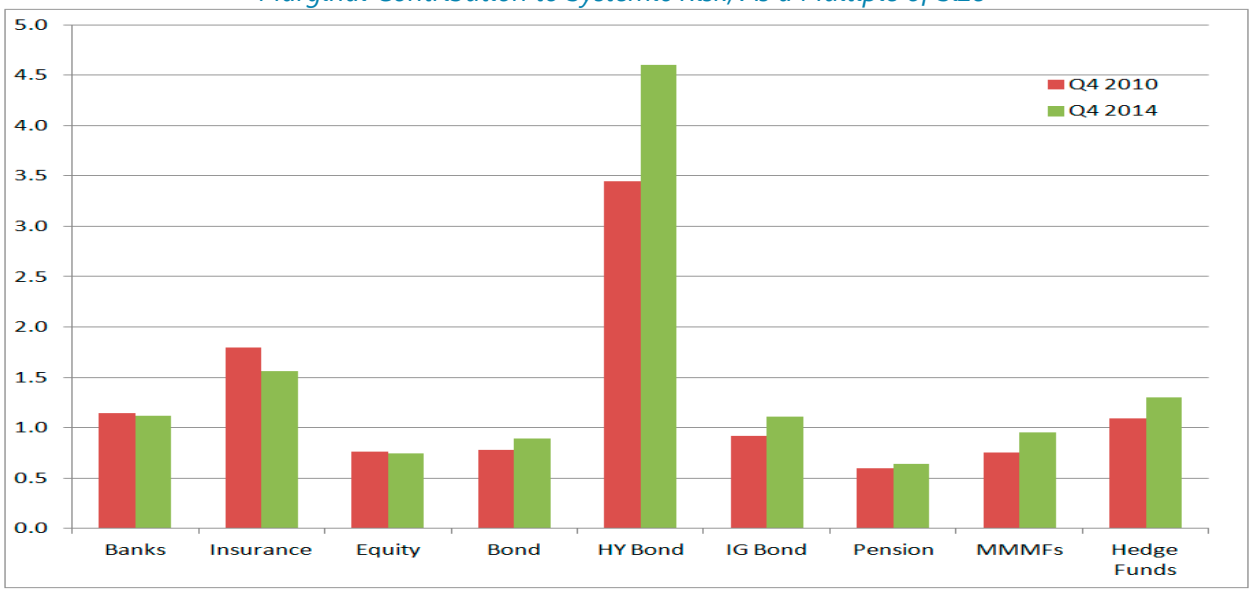
[92] See Box 3 and Chapter 2 of IMF (2014b) and Segoviano and others (2015) for additional details. SyRIN and CCA (presented later) are independent frameworks and their findings, definitions, and approaches to measuring systemic risk should not be conflated.

Figure 19. Systemic Risk Indicators Framework, 2010Q4 and 2014Q4

Sector Sizes (percent of total financial system assets)



Marginal Contribution to Systemic Risk, As a Multiple of Size



Source: IMF staff calculations based on methodology described in Segoviano and Goodhart (2009) and expanded in the October 2014 *Global Financial Stability Report* (IMF 2014b); and Segoviano and others (2015).

Note: The top chart shows sectors' shares of financial system total assets. The bottom chart shows each sector's contribution to systemic risk relative to its asset size. Ratios exceeding 1.0 indicate that the systemic importance of a given sector is greater than what would be suggested by asset size alone. In the SyRIN framework, "distress" is defined as an event whereby the index used to represent returns of a given sector falls to a level that should only be observed 1 percent of the time based on history. The SyRIN definition of "distress" is independent of the Contingent Claims Analysis (CCA) definition of "default." HY = high yield, IG= investment grade, MMMFs = money market mutual funds.

151. In sum, the findings of the Systemic Risk Dashboard suggest that although threats to financial stability have diminished since the peak of the crisis, they remain worthy of

continued close monitoring, especially with regard to nonbanks. Financial stability indicators in the United States have broadly improved, but areas of concern do exist, especially outside the banking system. Equity prices levels, housing price growth, and the vulnerability of banks to distress originating in the high yield and insurance sectors should be assessed more closely. The metrics presented thus far focus on historical developments in the financial system and serve as a baseline assessment. Against this background, the next section uses a hybrid market/balance-sheet framework known as Contingent Claims Analysis (CCA) to explore how financial risks may evolve under the IMF/DFAST stress scenario.

Box 3. Systemic Risk Indicators (SyRIN) Framework: A Primer

Contagion through interconnectedness across financial institutions and sectors plays an important role in the realization of systemic risk. The recent crisis underlined that proper estimation of contagion risks among financial institutions and sectors in a financial system is essential for effective financial stability assessment. The realization of simultaneous large losses in various entities would affect a financial stability, and thus represents a major concern for regulators. Thus, the analysis of systemic risk should aim at understanding these contagion risks (due to direct and indirect linkages across financial institutions) and their changes across the economic cycle.

The SyRIN framework used in the market-price based systemic risk assessment draws upon recent financial stability literature and a wealth of previous analytical work to estimate systemic risk. Earlier versions of this approach were used in the 2010 FSAP as well as the October 2014 Global Financial Stability Report (IMF, 2014b). The SyRIN employs distress-based metrics to assess the level of systemic risk present in a given set of financial sectors. The SyRIN framework is independent of the CCA analysis, and their findings, definitions, and approaches to measuring systemic risk should not be conflated.

The SyRIN framework conceptualizes the financial system as a portfolio of entities, which spans banks and non-banks alike, and incorporates the effect of interconnectedness into its risk estimates. Most empirical literature on systemic risk measurement has tended to focus on a single sector, typically the banking sector, without taking into account the rest of the financial system. Research concerned with analyzing risks associated with nonbank financial institutions has only recently started to emerge. By providing a comprehensive treatment of both bank and non-bank financial sectors, SyRIN is able to analyze system-wide risks in a manner consistent with empirical facts (Espinoza and Segoviano 2014). For the purposes of this Technical Note, the SyRIN portfolio includes the largest domestic banks, insurance companies, pensions, mutual fund and hedge fund sectors.

Contagion through interconnectedness in the financial system can happen due to direct and indirect linkages across sectors. Direct linkages occur through the direct exposure channel via inter-sector exposures (interbank deposits, lending, syndicated loans), derivative transactions and exposures counterparty bankruptcy. Indirect linkages can be due to exposures to common risk factors which surface in periods of economic and financial distress, either through the asset liquidation channel or through liquidity-induced fire-sales. Other associated factors include general increases in investor risk aversion during stress periods, the effect of "herding" on investor portfolio reallocation decisions, and actions taken by short-sellers to drive down stock prices for financial firms which follow complex or opaque business models or rely on embedded leverage.

SyRIN estimates are drawn from a multivariate joint probability density which accounts for financial system interconnectedness. This density models the distribution of asset price returns for a financial system portfolio that explicitly accounts for the dependence structure (defined in terms of direct and indirect linkages) of its portfolio components. This approach allows SyRIN estimates to capture the joint effect of changes in asset values for sectors throughout a financial system. To infer this density, SyRIN uses a robust, non-parametric approach that incorporates endogenous changes in sector co-dependence. When economic conditions

deteriorate, the density's "distress" dependence structure increases, thereby increasing its probabilistic estimates that sectors will fall into distress.

SyRIN uses a nonparametric multivariate density to measure financial stability from several complementary perspectives. Measurement takes the form of estimation (via simulation) of distressed losses to the financial system, and is the basis for the calculation of a given sector's MCSR. The MCSR captures the effect of portfolio sectors' interconnectedness (co-dependence) and relative size, and can be used in conjunction with complimentary joint and conditional probability estimates, which are also drawn from SyRIN's multivariate density, to round out its assessment of systemic risk.

B. Contingent Claims Analysis: Stress Testing for Systemic Risk

152. Contingent Claims Analysis (CCA)[93] uses equity prices and accounting information to measure the credit risk of institutions with publicly traded equity. The CCA framework is useful because it provides forward-looking default probabilities which take into account both leverage levels and market participants' views on credit-quality. Another benefit is that it provides a standardized benchmark of credit risk, known as default probabilities, that facilitate cross-sector and cross-country comparisons. However, CCA does suffer from some theoretical shortcomings. Namely, it can only be applied to entities with either publicly-traded equity or very liquid CDS spreads, and it cannot capture liquidity or (financing) roll-over risk. CCA risk measures are calculated at the firm-level and complement the high-level survey of risk measures presented in the systemic risk dashboard with micro-based information on financial risks.

153. The central idea behind CCA is that an institution's risk of default is driven by the level and uncertainty in its asset values relative to the promised payments on its debt obligations. Assets of a financial institution or corporation are uncertain and change due to factors such as profit flows and risk exposures. Default risk over a given horizon period is driven by uncertain changes in future asset values relative to promised payments on debt– where these payments are often referred to as the "default barrier". As first introduced by Merton (1973), the key financial insight used to quantify this asset/debt inter-relationship is that equity values can be modeled as an implicit call option on assets, with an exercise price equal to a default barrier, and that risky debt can be modeled as the default-free value of debt minus an implicit put option (i.e. an expected loss due to default). Accounting information on an institution's debts and market information on the price of its outstanding equity are used to calibrate CCA balance sheet risk indicators and to estimate forward-looking probabilities of default.

154. The CCA and SyRIN are two different frameworks that are independent of and complementary to each other; their findings, definitions, and approaches to measuring systemic risk should not be conflated. Importantly, CCA uses "default probabilities" as its measure of credit/default risk, whereas SyRIN uses "distress probabilities" in its financial risk estimates. CCA default probabilities are derived from a structural model (Merton, 1973) and signify the chance that

[93] For a fuller description of CCA, see the 2010 US FSAP Technical Note on Stress Testing July 2010 pages 59-62 and Appendix VIII pages 98 -99 and IMF WP 13/218.

the value of a given financial institution's (market-adjusted) assets will fall below a specific liability threshold (its default barrier). SyRIN distress probabilities are defined as the chance that the value of a given financial sector's market equity will fall below the 1st percentile value of its historical equity price distribution. Also, the sectors analyzed in the SyRIN and CCA approaches are not necessarily identical. For example, only SyRIN's analysis includes sectors such as pensions and high yield bonds funds and only CCA's analysis includes foreign banking and insurance sectors. (See relevant sections of the market-price based stress tests for additional details.)

CCA Stress Test Data

155. The historical default probability estimates used in the CCA stress tests were acquired from CreditEdge.[94] CreditEdge follows several broad steps in its production of this key stress testing input.

i. For each institution, daily equity values, equity volatilities, and default barriers are calculated.

ii. The inputs from step (i) are then used to simultaneously solve two structural CCA equations and estimate market-implied asset values and market-implied asset volatility.

iii. "Distance-to-default" indicators are computed using the inputs from the first two steps and are then mapped to empirically observed one-year default probabilities using Moody's extensive historical default database.

156. Default probabilities can also be mapped to credit-risk boundaries, such as credit spreads or ratings. Empirical research suggests that an approximate investment-grade "safe zone" for financial institutions corresponds to an expected one-year default probability of 0.5 percent or less.[95]

157. The CCA stress tests covered 210 institutions from a mixture of domestic and foreign domiciles and eight different sectors (Table 18). The eight sectors consisted of: domestic banks ("banks"); life, health, and property/casualty insurers ("insurers"); investment management companies, REITS, and private equity firms ("asset managers"); large, publicly-traded nonfinancial firms (corporates); other nonbank financial institutions (NBFIs), government sponsored housing enterprises ("GSEs");[96] all non-U.S. domiciled G-SIBs ("foreign banks"), and all G-SIIs as well as other large foreign insurers ("foreign insurers"). In addition, an overall U.S. financial system sector was created using data pooled from among all the domestic U.S. sectors, excluding GSEs.

[94] Data were generated using CreditEdge's 9.0 Public Firm Model. See Moody's Analytics EDF 9: Introduction and Overview (February 2015) for additional details.

[95] The safe zone boundary value is based upon extensive research by Moody's Analytics, shared with IMF staff.

[96] Due to data quality constraints, default probabilities for GSEs which correspond to the period following their conservatorship were omitted from the final results of the CCA stress tests.

Table 18. CCA Stress Test Sample Data		
	Number	**Selection Criteria**
Asset Managers	41	10 billion USD plus market cap
NBFIs	13	10 billion USD plus market cap
Insurers	44	20 billion USD plus market cap
Corporates	32	Includes the largest non-financial DJIA public companies, auto makers that received government support, "new economy" technology companies with large and rapidly growing market capitalization (e.g., Facebook)
Banks	46	20 billion USD plus market cap
GSEs	2	Must have entered government conservatorship
Foreign Banks	20	All foreign banks designated by the FSB as GSIBs
Foreign Insurers	12	All foreign insurers designated by the FSB as GSIIs plus the largest non-U.S. domiciled global insurers
Total	**210**	

Source: IMF staff calculations

158. The CCA stress tests utilized a connectivity variable and a number of credit risk and macroeconomic variables (Table 19). For comparability purposes, the macro variables used in the stress testing scenarios were identical to those used in the top-down balance-sheet based stress tests run for banks. Daily historical data was used in estimations and covered a ten-year period spanning end 2004Q3 to end 2014Q3. Additional information is listed below:

- Daily default probability data was acquired from CreditEdge and daily, monthly, and quarterly macroeconomic data was from obtained from Haver Analytics and Bloomberg.
- Inter-connectivity data was calculated by IMF staff, using the process outlined in the subsequent section on the stress testing methodology, on a rolling monthly basis over the period of 2004–2014.
- All quarterly and monthly variables, including connectivity, were temporally disaggregated to a daily frequency using the Chow-Lin Max-Log methodology. This includes all data contained in the baseline and stress scenarios as well.
- The connectivity measure used for projections was extended forward in time using the following two assumptions: (i) the connectivity trend which was observed in 2008–2010

would repeat itself, then (ii) remain at its post-crisis historical average once this value has reached.

- All default probabilities used in the CCA stress test models are median one-year, expected default probabilities. For each sector, daily median default probability time series were computed from observations pooled at the sector level. Daily U.S financial system median default probabilities were generated from observations pooled from all domestic sectors, excluding GSEs.

Table 19. Variables Used in CCA Stress Tests

Macroeconomic variables	
Real GDP growth rate	3-mounth Treasury rate
Nominal GDP growth rate	5-year Treasury yield
Real disposable income growth	10-year Treasury yield
Nominal disposable income growth	BBB corporate yield (10 year BBB-rated corporate bonds)
Unemployment rate	Mortgage rate (Freddie Mac data)
CPI inflation	Prime rate
House price Index (CoreLogic)	Dow Jones Stock Market index
CRE Price Index (Fed Z.1 release. FI075035503.Q)	VIX
Euro Area real GDP growth rate	USD/euro exchange rate
Euro Area inflation	Developing Asia dollar exchange rate (F/USD)
Developing Asia inflation	yen/USD exchange rate
Japan real GDP growth	USD/pound exchange rate
Japan inflation	
UK real GDP growth	
UK inflation	
Credit risk variables	**Connectivity variables**
Expected 1-year default probabilities	Global clustering coefficient score

Source: IMF staff.

CCA Stress Test Methodology

159. To estimate the relationship between connectivity, macroeconomic factors, and median default probabilities, the CCA stress tests utilized a class of models known as General Adaptive Models of Location, Shape, and Scale (GAMLSS). GAMLSS, described in detail in Stasinopoulos and Rigby (2007), is an extremely flexible model class which allows one to: (i) utilize a wide variety of distributions to characterize the response variable and (ii) explicitly model the first four moments of these distributions as functions of exogenous conditions. As a result, the framework is well suited to address the presence of tail-risks, nonlinearities, and deviations from the normality assumption. The default probability data used in the CCA exercise exhibited all of these latter characteristics, thereby motivating the choice of the GAMLSS model class for stress testing purposes.

160. The GAMLSS modeling process follows an iterative approach consisting of eight steps.

i. Fit approximately 100 different distributions to the response variable (i.e., median 1-year default probabilities).

ii. Compare the quality of each fit using the Generalized Akaike Information Criteria (GAIC) and select the distribution with the best score.

iii. Using the distribution chosen in step (i), run information criteria based selection procedures97 to identify the independent variables with the most linear explanatory power.

iv. For variables not selected in step (iii), transform them using additive terms (e.g., orthogonal polynomials, penalized basis splines, etc.) and repeat the prior step's selection procedure.

v. Once a final set of independent variables has been determined, experiment with different additive terms to enhance model fit.

vi. Compare all experimental models generated in step (v) using the GAIC and select the model with the best score.

vii. Repeat steps (i) through (vi) for each distributional parameter (i.e., the mean, variance, skewness, and kurtosis).

viii. Use diagnostics to assess whether the model residuals are supportive of the assumed response distribution. If not, return to step (i) and repeat the process using the next best GAIC-identified distribution.

161. To avoid over-fitting and to test the out-of-sample predictive power of stress test projections, stiff penalties[98] were imposed on model complexity when computing GAIC-based model selection scores and a back-testing regime was used throughout the modeling process. The back-testing regime consisted of (i) using a quantile-based sampling algorithm[99] to partition the overall dataset into separate validation, testing, and training datasets, and (ii) using the validation dataset for calculating initial distributional fits; using the training dataset to estimate the regression coefficients and for variable selection; and using the testing dataset to gauge out-of-sample model performance.[100]

[97] The model selection procedure is a generalized version of the AIC-based algorithm of Venables and Ripley (2002). The procedure performs forward and backward model selection over a model space that is bounded by user-specified lower and upper limits on model complexity. The selected model will have the highest GAIC among all possible models considered and will exhibit a level of complexity which is somewhere between that of the lower and upper complexity limits.

[98] Following suggested best practice (Kim and Gu, 2004), a penalty value of k=2.8 was selected when computing GAIC scores.

[99] Quantile-based sampling was used to create data partitions by first splitting a dataset into quasi-homogenous subgroups, where group membership was based on percentile values, and then performing random sampling within each subgroup. This method of random sampling is used to preserve the distributional structure of samples drawn from each split of the response variable and to help balance the data partitions.

[100] Out-of-sample model performance was assessed by comparing the global deviance and mean prediction error scores of training and testing dataset model fits. Large discrepancies in scores suggest poor out-of-sample performance.

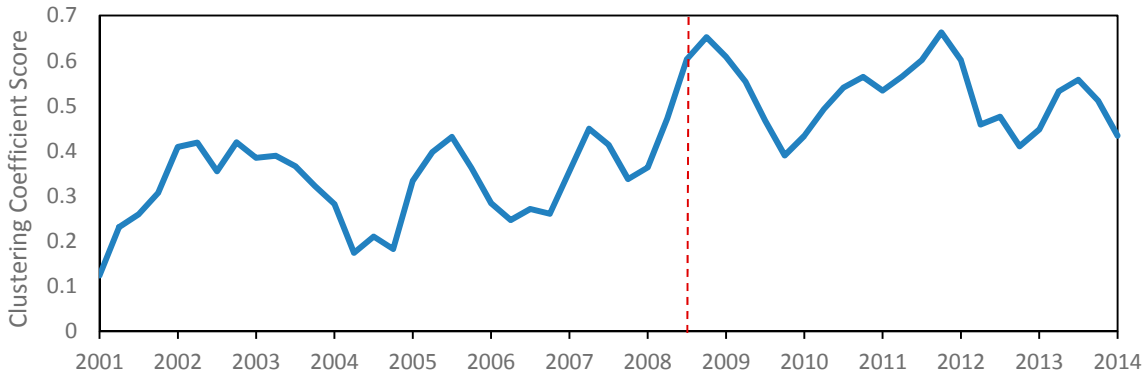
162. The GAMLSS model for the overall U.S. financial system suggests that macroeconomic, sector credit risk, and interconnectivity factors influence credit risk levels in the United States in significant, and often non-linear, ways. The model finds that median 1-year default probabilities for the U.S. financial system are expected to fall linearly with rises in long-term Treasury yields, housing and commercial real-estate prices and with appreciation of the U.S. dollar against the Euro. Default probabilities are expected to increase linearly with BBB-rated corporate bond yields and bank, insurer, asset manager, other non-bank financial institution, foreign bank, and foreign insurer median default probabilities. The magnitude of these co-movements differs by for each variable, but changes in BBB corporate bond yields, long-term Treasury yields, and asset manager default probabilities have some of the greatest effects on financial system credit risk. The model also finds many non-linear relationships. U.S. credit risk slightly rises with euro-area consumer inflation, and falls with declines in real GDP growth and the VIX and Dow Jones Industrial indices. Overall credit risk in the U.S. also rises with increases in corporate credit risk, but only in non-linear statistically significant manner. A simplified summary of the final specification for the overall U.S. financial system model is presented in Appendix Table 5. Appendix Figure 8 shows the estimated relationships for the model's four non-parametric additive terms.

163. A single connectivity measure was calculated and used as an explanatory variable in each of the estimated GAMLSS models. This connectivity measure was calculated using institutional-level default probability time-series data from the following five domestic sectors: banks, insurers, asset managers, other non-bank financial institutions, and nonfinancial corporates. This measure, formally known as a "global clustering coefficient", was derived using the following three-step process:

- Perform Spearman Rank Correlation Tests to identify institutional default probabilities that are correlated at the .0001 percent significance level.
- Construct an adjacency matrix from the test results, and use this matrix to derive a "correlation network."
- Calculate the network's global clustering coefficient score.

The above three-step process was repeatedly applied to one-month rolling windows spanning the period of 2004Q3 to 2014Q3. Monthly values were then temporally disaggregated using the Chow-Lin Max-Log methodology to generate a daily connectivity time series. Figure 20 shows the corresponding quarterly series, which was calculated using both domestic and foreign sectors. The figure underscores the increase in connectivity over time. Statistical tests suggest that a structural break occurred in 2008. After the break, connectivity has a higher mean and lower variance, suggesting that the financial system is more "consistently connected" post-2008.

Figure 20. Financial System Connectivity



Source: IMF staff calculations based on data from Moody's CreditEdge.
Note: The clustering coefficient measures network connectivity on a scale from 0 to 1 and its values reflect the probability that a set of points within a given network will share a direct relationship. The clustering coefficient scores for the U.S. financial system were calculated by first applying correlation tests to one-year, rolling windows of firm-level measures of default risk and assessing the clustering present in these test results. The correlation tests are based on two-sided, non-parametric Spearman rank correlation tests, performed at the 0.001 percent significance level. The score at each point in time represents the connectivity present between firms with highly correlated default risk over the prior year-to-date. The firm-level measures of default risk used in the underlying calculations were monthly default probabilities for approximately 210 domestic and foreign entities. The red line is a structural break, as identified by a pruned exact linear time (PELT) mean-variance test performed at a 1 percent significance level. Connectivity has a higher mean and lower variance after the break which suggests that the financial system is more "consistently connected" post-2008.

CCA Stress Test Results

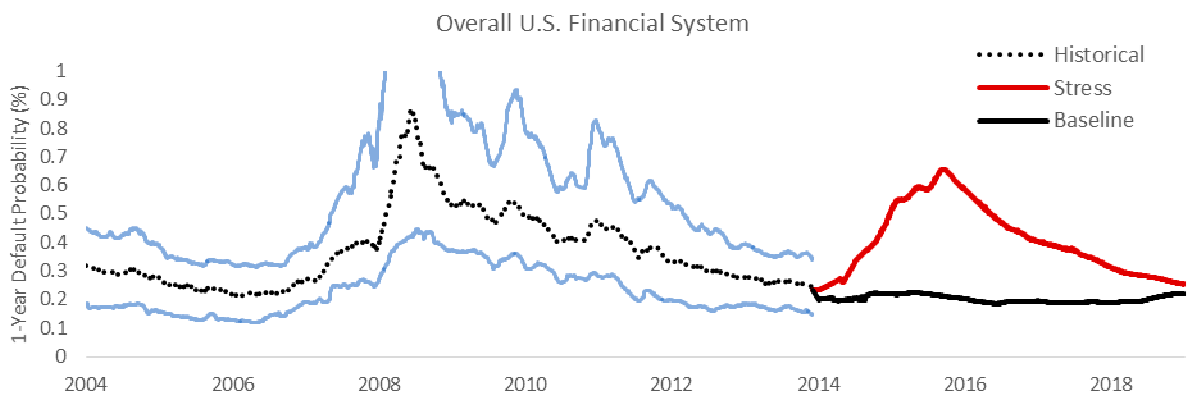
164. The CCA stress tests estimated the relationship between connectivity, the macroeconomic environment, and median default probabilities using separate GAMLSS models for each sector and for the overall U.S. financial system. These models were used to assess the impact of macroeconomic changes and fluctuations in connectivity under the "baseline" and "stress" scenarios and to individually project default probabilities for the overall U.S. financial system and for five domestic and two foreign sectors. The CCA stress test scenarios are identical to those used in the balance sheet stress tests for banks (i.e., identical to the IMF/DFAST scenarios). In order to isolate the impact of potential spillovers, the CCA stress tests controlled for a number of different factors. The use of quantile-based default probabilities served as a control for idiosyncratic risk at the firm level. The presence of macro variables with high explanatory power in the estimated regressions was used to control for macroeconomic risks and the inclusion of a statistically significant connectivity measure was used as a control for other relational changes between sectors.[101] Given

[101] Specifically, the connectivity measure was used to assess whether changes in default probabilities of one sector could be directly/indirectly attributed to changes in the credit risk of another sector.

these controls, the relationships estimated between sector default probabilities are believed to effectively capture the effect of intersectoral spillovers.

165. Under the stress scenario, expected one-year median default probabilities for the U.S. financial system are projected to increase from 0.20 percent to 0.65 percent, about two-thirds the level seen at the height of the 2008–09 financial crisis. Figure 21 shows the historical evolution of overall system median default probabilities along with forecasts under the baseline and stress scenarios. On average, default probabilities for all sectors (Appendix Figure 9), are expected to increase to about two thirds of their 2008–09 levels, with the exception of corporates and asset managers which are expected to experience smaller increases. Using a threshold of 0.5 percent or lower as a low credit risk boundary,[102] under the stress scenario banks, insurers, NBFIs, and foreign banks exit this "safe zone" during the period of peak stress which occurs in 2015–16. Corporates, asset managers, and foreign insurers never breach this boundary though, even under severely adverse macroeconomic conditions. Only projections for the overall U.S. financial system model explicitly take into account changes in the estimated default probabilities of other sectors. Individual sector projections (Appendix Figure 9) were generated exclusively using macroeconomic and connectivity factors.

Figure 21. U.S. Financial System Median Default Probability Forecast



Source: IMF staff calculations.
Note: Blue lines indicate 25th and 75th percentile values of the distribution of historical estimates of U.S. institution 1-year ahead default probabilities. The dashed black line denotes the median value of the distribution of historical estimates of U.S. institution 1-year ahead default probabilities. The solid red and black lines denote median 1-year ahead default probabilities projected by the CCA stress tests under the stress and baseline scenarios, respectively. To better show projection details, the y-axis has been truncated at 1 percent. The line denoting the 75th percentile reached a maximum value of 2.5 percent in 2008-09. Only projections for the overall U.S. financial system model explicitly take into account changes in the estimated default probabilities of other sectors. Individual sector projections (Appendix Figure 9) were generated exclusively using macroeconomic and connectivity factors.

[102] The threshold value of 0.5 percent is based upon extensive research done by Moody's Analytics and was conveyed to IMF staff via personal communication.

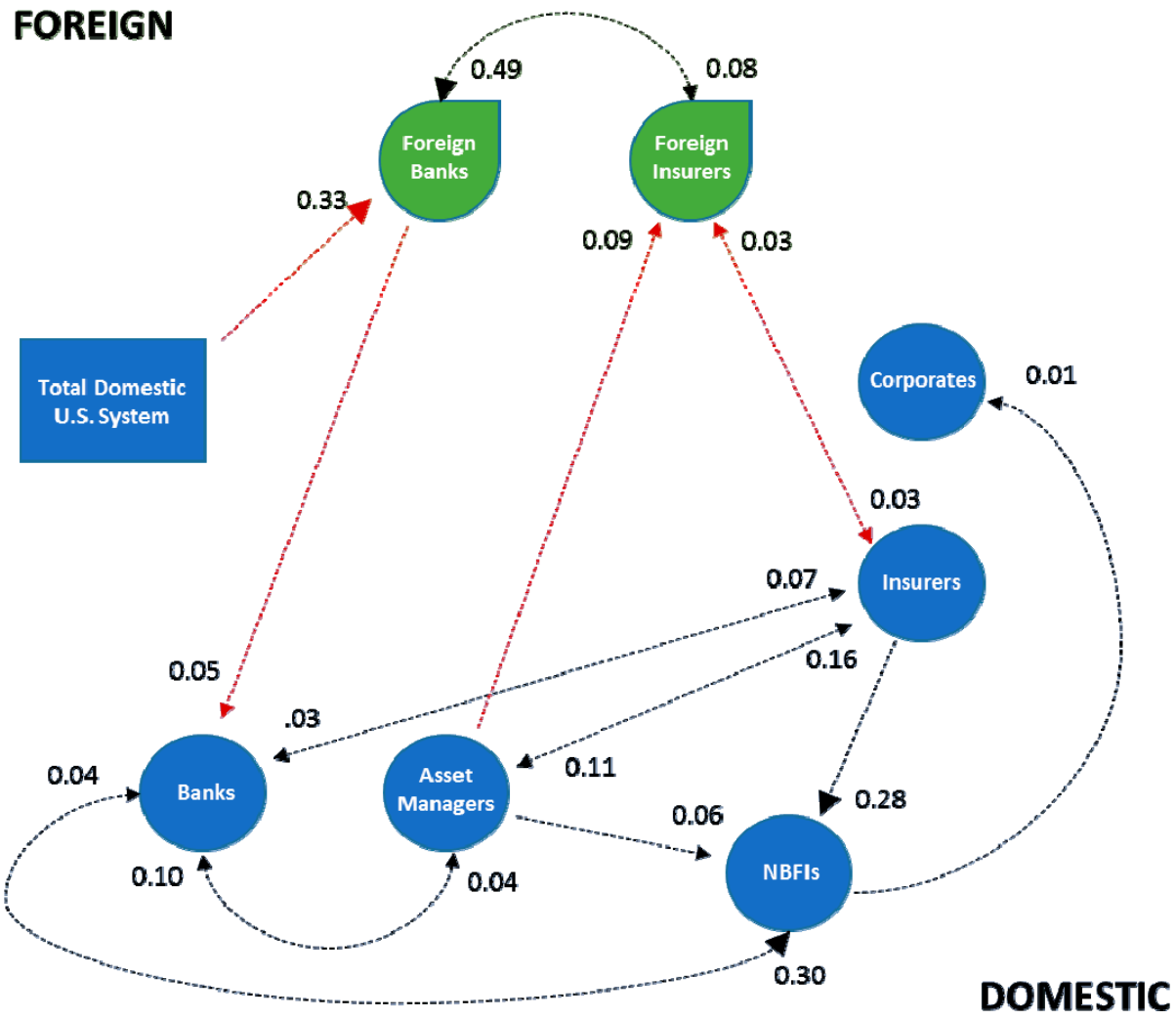
166. The analysis shows the importance of spillovers across sectors. Spillovers from the United States to the rest of the world were found to be large, but spillbacks from rest of the world to the United States appear relatively limited. The estimated effect of credit risk shocks (Figure 22) varies from sector to sector, but several observations are worth noting.

- Shocks to the credit profiles of U.S. asset managers, NBFIs, insurers, and foreign banks increased U.S. bank credit risk the most.[103]
- Increases in overall U.S. credit risk and credit risk in foreign insurers most negatively impacted the foreign banking sector, whereas the foreign insurance sector is most negatively affected by adverse changes in the credit profile of U.S. asset managers and insurers.
- The effect of a rise in default risk in foreign banks and foreign insurers on U.S. default risk appears small. Excluding the impact of macro factors, non-U.S. domiciled banks and insurers were found to collectively account for only 3 percent of median U.S. default probabilities. Under the 2015–16 peak period of the stress scenario, this contribution is projected to fall by an additional one-third, to 2 percent of the total attributable to non-macro factor components.

[103] The effect of insurers on banks may appear quantitatively smaller than suggested by the SyRIN approach used in the previous section. This reflects methodological differences between the two approaches, namely the fact that SyRIN focuses on the joint probability of distress, while the present approach explicitly takes into account the effect of macroeconomic variables on probabilities of distress. In other words, there are risks of spillovers from insurers to banks, but they partly reflect common (macroeconomic) factors.

Figure 22. Spillover Map

Effect on Sector X of a 0.5 percent Default Probability Increase in Sector Y



Source: IMF staff calculations.

Note: The figure shows the marginal contribution (in percent) of a one-time shock on a recipient sector's default probabilities given a severe 50 basis point (0.5 percent) shock to an originating sector's default probabilities. The results were calculated using the GAMLSS inter-sector relationships estimated as of end 2014Q3. Sector end of period default probabilities were separately increased by 50 basis points and shocks were measured as the deviation in a recipient sector's probability of default from its unshocked historical baseline. Dashed red lines denote cross-border effects of credit risk shocks. For this exercise, spillover effects were captured by incorporating historical estimates of median sector default probabilities as independent variables into the final specification of each of the sector projection models used to generate the results shown in Appendix Figure 8.

RECOMMENDATIONS FOR IMPROVEMENT

167. While the authorities' solvency stress test for BHCs are well advanced, and state-of-the-art in many respects, there is scope for enhancement. It would be useful to try to link liquidity, solvency and network analysis in a systemic risk stress testing framework. For example, Bank of Canada's Macro Financial Risk Assessment Framework captures the various sources of risk (solvency, liquidity and spillover effects) within a single stress testing framework (Bank of Canada, 2014). Moreover, reexamining some of the solvency stress test assumptions to make them consistent with historical evidence would be useful. For example, there may be merit in reexamining the stress test assumptions on loan and asset growth as well as dividend distribution.

168. Increasing the coverage of the tests would be helpful. In particular, the FRB should include the largest SLHCs in the supervisory stress tests once they start performing company-run stress tests (from 2017).

169. Establishing a regular liquidity stress testing framework for banks will be an important further step. The announced Comprehensive Liquidity Analysis and Review (CLAR), that is expected to be launched by the end of 2015, is a step is the right direction. This will complement the solvency testing under the DFA.

170. Another area for improvements relates to modeling network contagion. The network contagion exercise here illustrates the need to expand the FRB's data on interbank exposures to include a richer set of dynamics and a broader range of counterparties.

171. In insurance, the focus should be on developing and performing insurance stress tests on a consolidated, group-level basis. This is especially important for groups that are (i) designated as systemically important; (ii) engaged in material group-internal risk transfer, e.g., via captives; or (iii) exposed to non-linear market risks through the sale of products which include guarantees or optionalities, e.g., variable annuities. It would also be useful to improve public disclosure by requiring insurance companies to disclose market risk sensitivities in a more harmonized manner.

172. Regular system-focused liquidity risk analysis for the mutual fund industry should be done on a regular basis. At present, a considerable range of bottom-up analyses is performed by the industry. According to the authorities, rule-making is forthcoming to standardize stress tests by mutual funds with consolidated assets of $10 billion or more. The authorities are encouraged to further clarify the guidance to the industry on liquidity risk analysis, and to start conducting regular top-down analysis to provide a more holistic picture of the industry's contribution to systemic risk.

173. The authorities are encouraged to conduct more intensive monitoring of systemic financial sector risks, including the use of market-based solvency and shortfall measures. Market-price based stress tests employ forward-looking, higher-frequency, market consensus information that, when used appropriately, can add value to traditional stress tests in a variety of ways. While the market-price based analysis has its limitations, it can be a useful "cross-check" to corroborate the findings of other stress test methodologies. They can also be readily extended to assess the safety and soundness of sectors which are not traditionally subject to bank-like supervisory oversight.

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Appendix I. Risk Assessment Matrix and Stress Test Matrix

Appendix Table 1. Risk Assessment Matrix

Nature/Source of Risk	Likelihood of Severe Realization of Threat in the Next 1–3 Years	Expected Impact on Financial Stability if Threat is Realized
1. Abrupt surge in market volatility	**High** Recent compression in volatility and risk premia could unwind. Stress in credit markets (especially cov-lite loans) could be exacerbated by increased exposure to more risky borrowers, rising leverage, and weaker underwriting standards. Impaired trading liquidity for high yield issues could aggravate the risks. Bond repricing could lead to a run on mutual funds. Run risk may be intensified by the increased holdings of retail investors (over the past five years, the share of credit instruments held by retail funds has increased substantially, to 37 percent of total credit holdings). Duration and interest rate risk could materialize, as they are both at recent historical highs and financial institutions' portfolio allocations to fixed income instruments remain above the recent historical trend.	**High** A 50 bps permanent increase in 10-year interest rates could subtract about ½ percent of GDP after two years. Spikes in term premia could imply greater output losses. Runs from mutual funds can lead to a vicious feedback loop between outflows and asset performance.
2. Imbalances from protracted period of low interest rates	**Medium** Search for yield leads to excess leverage, weaker underwriting standards and potential mispricing of risk. Continued low interest rates can give rise to new configuration of risk in the insurance and pension fund industry. In combination with the relatively weaker supervision in the nonbank sector, this can further increase intermediation outside the banking system and purchases of riskier assets by traditional and shadow banking system (e.g. asset managers).	**High** If unaddressed, distortions could lead to financial instability with significant economic costs and large spillovers to the rest of the world.
3. Operational risk	**High** Operational risk stemming from, for example, software or hardware failure, a cyber event, or a major natural disaster.	**Medium** Disrupting or destroying a critical infrastructure can lead to sizeable impacts on the financial system. For instance, if a large solar storm similar in size to the 1859 event hit the world now (an event with an estimated 12 percent likelihood in the next 10 years), cost estimates are 2 trillion dollars with power and satellite outages lasting for months.

Appendix Table 1. Risk Assessment Matrix (concluded)

	Likelihood of Severe Realization of Threat in the Next 1–3 Years	Expected Impact on Financial Stability if Threat is Realized
4. Protracted period of slower growth and lower inflation in advanced and emerging economies	**High** Lower-than-anticipated potential growth and persistently low inflation leads to secular stagnation in advanced economies. Maturing of the cycle, misallocation of investment, and incomplete structural reforms leads to prolonged slower growth in emerging markets.	**Medium** Slower growth in advanced and emerging economies could subtract about ½ percent of GDP after two years.
5. Geopolitical risks	**Medium** Spillover effects from increased geopolitical tensions surrounding Russia/ Ukraine; heightened geopolitical risks in the Middle East, leading to a sharp rise in oil prices.	**Low** Geopolitical tensions would create significant disruptions in global financial, trade and commodity markets. A rise in oil prices would have a negative impact on the U.S. economy and financial sector with a possible flight to safety resulting in dollar appreciation. A sustained 15 percent increase in oil prices above baseline would subtract about 0.2 percent of GDP after two years.
6. Bond market stress from a reassessment in sovereign risk	**Low** Interest rates could spike if the budget is not passed in 2015 or the federal borrowing limit is not raised (owing to political gridlock). Protracted failure to agree on a credible plan for fiscal sustainability could lead to a rise in the risk premium.	**High** The economic cost of a sharp rise in the sovereign risk premium could be sizeable. If the budget impasse lasts, it could have severe global spillovers. A 200bps increase in the benchmark Treasury yields would subtract 2.5 and 1.5 percentage points from U.S. growth in 2015 and 2016, respectively.

Note: The risks are ordered first by impact (high to low), and second by likelihood (high to low).

Appendix Table 2. Stress Test Matrix: Solvency, Liquidity, and Network Effects				
Domain		**Assumptions**		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
BANKING SECTOR: SOLVENCY RISK				
1.Institutional Perimeter	Institutions included	• 31 largest bank holding companies (with total consolidated assets of $50 billion or more)		
	Market share	• 85 percent of total banking holding companies' assets		
	Data and baseline date	• BHCs' own data • Consolidated banking group • Baseline date: 2014 Q3	• Supervisory data (FR Y-14) • Consolidated banking group • Baseline date: 2014 Q3	• Publicly available data (FR Y-9C) • Consolidated banking group • Baseline date: 2014 Q3
2. Channels of Risk Propagation	Methodology	• BHCs' internal models consistent with supervisory expectations	• Fed's top-down approach similar to balance sheet-based approach based on granular data	• Balance sheet-based approach
	Satellite Models for Macro-Financial linkages	• Macro-financial linkages: Companies were required to calculate, under the scenarios mentioned over the stress horizon, potential losses, pre-provision net revenue, provision for loan losses and capital levels. The FRB generally expects BHCs to use model or other quantitative methods for estimating profits and balance sheet items or process that are well supported, transparent and repeatable in instances where qualitative approaches are more appropriate. • A general expectation was that: (i) companies develop internal models that best capture their	• Macro-financial linkages: Pre-provision net revenue was forecasted using a series of autoregressive models that relate the components of a BHC's revenues and non-credit-related expenses, expressed as a share of relevant asset or liability balances, to BHC characteristics, and to macroeconomic variables; the models were developed using pooled historical data from many financial institutions, either supervisory data collected by the FRB or proprietary industry data. • The projections of revenues, expenses, and losses were based on the Fed's projections of the	• Macro-financial linkages: income statement items and balance sheet items (loans and trading assets) were modeled and forecasted using: (i) panel regression with fixed effects, (ii) univariate regression models using aggregate data (for trading income, AOCI and provisions effects). Both types of models included macro variables as explanatory variables.

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
		risks, rather than relying on models that closely mirror supervisory models, (ii) Data used should have contained sufficiently adverse outcomes, (iii) balance sheet and net income items to be projected at sufficient granularity. • Companies used a range of quantitative approaches to estimate losses. These include loan losses, losses of available-for-sale and held-to-maturity securities, operational risk losses, trading losses. • Methods used to estimate loan losses ranged from accounting based loss approach (charge-off and recovery) or expected losses (calculated a function of probability of default, loss given default and exposure at default). Projections of income statement items should have been consistent with scenario conditions and the current and projected paths of on and off balance sheet exposures.	balance sheet for each BHC **over** the planning horizon. Most components of pre-provision net revenue which contained consolidated income statement and balance sheet information for each BHC (including components of interest income, noninterest income, and noninterest expenses) were projected using data on historical revenues and operating and other non-credit-related expenses reported on the FR Y-9C report. • Loan losses were projected separately for different categories of loans based on the type of obligor (e.g. consumer, commercial loans), collateral (e.g. residential real estate, CRE), loan structure (e.g. revolving credit lines) and accounting treatment (accrual or fair value). Loan data and information about loan portfolios, including borrower characteristics, collateral characteristics, characteristics of the loans or credit facilities, amounts outstanding and yet to	

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
			be drawn down (for credit lines), payment history, and current payment status came from FR Y-14 report. Data were collected on individual loans or credit facilities	
	Stress test horizon	• 2014Q4-2016Q4	• 2014Q4-2016Q4	• 2014Q4-2019Q4
3. Tail shocks	Scenario analysis	• **Baseline:** reflected the average projections from the most recently available consensus view of the macroeconomic outlook expressed by professional forecasters, government agencies and other public sector organizations • **Adverse:** represented conditions that are more adverse than those in the baseline scenario but less severe than those in the severely adverse scenario. It was formulated as one-half or two-thirds of the deviation of the paths of the variables relative to the baseline or severely adverse scenario. It also includes specific risk assumptions not found in the other scenarios, such as the rise in short-term interest rates. • **Severely adverse (stress):** reflected conditions of a typical or	• **Baseline:** reflected the average projections from the most recently available consensus view of the macroeconomic outlook expressed by professional forecasters, government agencies and other public sector organizations • **Adverse:** represented conditions that are more adverse than those in the baseline scenario but less severe than those in the severely adverse scenario. It was formulated as one-half or two-thirds of the deviation of the paths of the variables relative to the baseline or severely adverse scenario. It also includes specific risk assumptions not found in the other scenarios, such as the rise in short-term interest rates. • **Severely adverse (stress):** reflected conditions of a typical or	• **Baseline:** DFA baseline scenario, broadly similar to IMF projections that follow the January 2015 WEO; • **Stress:** DFA severely adverse scenario that characterizes a V-shaped recession over 2014Q4-2016 followed by a three year recovery.

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
		specific recreation of a post-war U.S. recession. In the scenario unemployment rate rose by a 4 percentage point rise over a two-year period. Real GDP was 4.5 percent lower than the baseline by the end of 2015 (GDP growth rates were negative for 5 quarters), equity prices fell by 60 percent in one year, house prices declined by 25 percent over the first two years, corporate spreads rose by 330 basis points, and mortgage rates increased by 80 basis points. • BHCs' developed scenarios: baseline and severely adverse which reflected a company's idiosyncratic risks and unique vulnerabilities to different factors including firm-specific events	specific recreation of a post-war U.S. recession. In the scenario unemployment rate rose by a 4 percentage point rise over a two-year period. Real GDP was 4.5 percent lower than the baseline by the end of 2015 (GDP growth rates were negative for 5 quarters), equity prices fell by 60 percent in one year, house prices declined by 25 percent over the first two years, corporate spreads rose by 330 basis points, and mortgage rates increased by 80 basis points.	•
	Sensitivity analysis/one time add-on shock	• Global market shock: an add-on shock applied to six companies with significant trading activity to their trading book and private equity positions (including their CVA) as of October 16, 2014; entailed estimating trading and counterparty mark-to-market losses and incremental default risk	• Global market shock: an add-on shock applied to six companies with significant trading activity to their trading book and private equity positions (including their CVA) as of October 16, 2014; entailed estimating trading and counterparty mark-to-market losses and incremental default risk	• Interest rate spike in 2015 • Oil price shock (large drop in 2014-2015) • Provisions modeled as net charge offs in a panel regression framework, also by loan types • Constant dividend distribution • Constant loan supply and total assets growing at 2.5 percent per year

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
		on their trading exposures. This shock consisted of moves in market prices and rates, much larger than in any scenario provided by the supervisors and was assumed to be an instantaneous event which immediately affects the market value of the trading assets and liabilities. • Counterparty default shock: an add-on shock involved the instantaneous and unexpected default of the companies' counterparty with the largest net stressed losses as of October 16, 2014. This shock was applied to eight large and highly interconnected companies. The shock was applied to companies' securities lending and repurchase/reverse repos and derivative exposures.	on their trading exposures. This shock consisted of moves in market prices and rates, much larger than in any scenario provided by the supervisors and was assumed to be an instantaneous event which immediately affects the market value of the trading assets and liabilities. • Counterparty default shock: an add-on shock involved the instantaneous and unexpected default of the companies' counterparty with the largest net stressed losses as of October 16, 2014. This shock was applied to eight large and highly interconnected companies. The shock was applied to companies' securities lending and repurchase/reverse repos and derivative exposures.	• No operational RWAs in calculation of total RWAs • DFAST hurdle rates
4.Risks and Buffers	Risks/factors assessed (How each element is derived, assumptions)	• Credit risk (granular sectoral exposures).	• Credit risk (granular sectoral exposures). • Tax rate: After-tax net income (or loss) was calculated by applying a consistent tax rate to pre-tax net income (or loss) for all BHCs.	• Credit risk (households, corporates, sovereign, financial institutions exposures). • Taxes: set at the pooled average tax rate over the last 20 years

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
	Behavioral adjustments	• It was expected that companies project balances for each major segment of the balance sheet consistent with scenario conditions and competitive and strategic factors. • For supervisory scenarios two sets of capital actions were used. One using BHC's planned capital action and one using the DFA stress test capital action assumptions. For BHC-defined scenarios the companies used planned capital actions- a BHC's planned capital actions under the BHC-baseline scenario and alternative capital actions- a BHC's assumed capital action under the BHC stress scenario • Under the DFA stress test capital action assumption, for the first quarter of the stress horizon, companies took into account its actual capital actions as of the end of the calendar quarter. For each of the second through ninth quarter, companies were required to use a standardized set of capital action assumptions that are specified in the Dodd-Frank Act	• The FRB projection of BHC balances sheets began with a set of models that relate total assets in the banking industry and important subcomponents, such as total loans and non-loan assets, to nominal GDP and other macroeconomic factors, including a measure of loan supply. These relationships were estimated using aggregate data and were used to project the growth in industry assets and its subcomponents over the planning horizon under each of the supervisory scenarios. • In the adverse and severely adverse scenarios, the measure of loan supply was assumed to remain at its long-run historical average over the planning horizon • Industry assets, loans, and trading assets were allocated to each BHC based on its shares of these positions at the beginning of the planning horizon. • All types of loans at all BHCs were assumed to grow at the same rate, which meant that the mix of loans at each BHC was constant over the planning horizon.	• Balance sheet growth and deposits growth were assumed to be equal to credit growth modeled and forecasted using a panel regression with fixed effects and macro variables as exogenous variables • Dividend payout schedule followed capital conservation rule also taking into account GSIB surcharge; BHCs could distribute maximum dividend amount equal to dividend payout ratio (dividends over net income) in the base-year if they are not capital constrained; dividends were paid out only if bank records profits. • Asset disposals and acquisitions over time were not considered; the portfolio composition remained unchanged over time, with maturing exposures replaced with similar ones.

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
		stress test rules. The assumptions were the following: (i) Common stock dividend payments were assumed to continue at the same level as the previous year; (ii) Scheduled dividend, interest or principal payments on any other capital instrument eligible for inclusion in the numerator of a regulatory capital ratio were assumed to be paid; (iii) No redemption or repurchase of any capital instrument eligible for inclusion in the numerator; (iv) New common stock, preferred stock or other instruments that would be included in regulatory capital, except for common stock issuance associated with expensed employee compensation, could not be issued.	• Trading assets were assumed to grow at the growth rate of total assets, adjusted for changes in mark-to-market values reflecting industry-wide trading asset composition, while non-loan assets other than trading assets and securities grew at the same rate for all BHCs. • Securities growth at each BHC was set so that total asset growth equals the projected rate given the growth of other types of assets at that firm. • Balance sheet projections incorporated expected changes to a BHC's business plan, such as mergers, acquisition, and divestitures, that are likely to have a material impact on the its capital adequacy and funding profile • Any capital actions that are designed to offset the impact of the stress scenario on the bank are not allowed • Under the DFA stress test capital action assumption, for the first quarter of the stress horizon, companies took into account its	

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
			actual capital actions as of the end of the calendar quarter. • For each of the second through ninth quarter common stock dividend payments were assumed to continue at the same level as the previous year	
5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• Company own calibration of parameters	• PDs were generally modeled as part of a transition process in which loans move from one payment status to another (e.g., from current to delinquent) in response to economic conditions. LGD were typically defined as a percentage of EAD and was based on historical data.	• Total RWAs were modeled (in a panel regression) as a function of total assets and interest rates to make RWAs risk sensitive • 2015 switch to standardized approach to calculate RWAs was calibrated using Fed's estimate of RWAs using standardized approached and using generalized approach • Operational RWAs (for advanced approaches BHCs that exited the parallel run) were assumed to grow with total assets
	Regulatory/Accounting and Market-Based Standards	• Capital standards: The capital definition corresponded to that required by local regulation, i.e., Basel III for advanced approaches BHCs and non-advanced approaches BHCs (from January 1, 2015) and Basel I for non-advanced approached BHC for the first quarter of the stress test	• Capital standards: The capital definition corresponded to that required by local regulation, i.e., Basel III for advanced approaches BHCs and non-advanced approaches BHCs (from January 1, 2015) and Basel I for non-advanced approached BHC for the first quarter of the stress test	• Capital standards: Basel III capital standards for all BHCs (CET1 estimated for non-advanced approaches BHCs); standardized approached to calculating RWAs from January 2015 • Hurdle rate: Basel III schedule (regulatory minimum for CET1), capital conservation buffer, GSIB

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
		horizon (last quarter of 2014). Companies were required to assume consistency with the Basel III transition schedule • Starting in 2015, the revised capital framework introduced a new standardized approach for risk weighting assets, which replaced the calculation of risk weights using the general risk-based capital approach. • Capital metrics: Tier 1 common capital ratio, common equity tier 1 ratio, Tier 1 capital ratio, total capital ratio and tier 1 leverage ratio	horizon (last quarter of 2014). Companies were required to assume consistency with the Basel III transition schedule • Starting in 2015, the revised capital framework introduced a new standardized approach for risk weighting assets, which replaced the calculation of risk weights using the general risk-based capital approach. • Capital metrics: Tier 1 common capital ratio, common equity tier 1 ratio, Tier 1 capital ratio, total capital ratio and tier 1 leverage ratio • Hurdle rates: Basel III minimum capital requirements; capital conservation and GSIB surcharge were not considered as part of hurdle rates	capital surcharge (using FSB buckets); phase ins of deductions from CET1 (for all BHCs) and phase outs of AOCI were also taken into account (from advanced approaches BHCs)
		• Risk-weighted assets: generalized approach (2014Q3-2014Q4); standardized approached to calculating RWAs from January 2015 • RWAs were projected based on corresponding projections of on- and off-balance sheet exposures and their risk attributes were	• Risk-weighted assets: generalized approach (2014Q3-2014Q4); standardized approached to calculating RWAs from January 2015 • Two components of RWAs were projected: market RWAs and two types of credit RWAs, generalized RWAs under the capital framework	• Risk-weighted assets: generalized approach (2014Q3-2014Q4); standardized approached to calculating RWAs from January 2015 • Total RWAs were modeled (in a panel regression) as a function of total assets and interest rates to make RWAs risk sensitive

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
		consistent with the scenario conditions	and standardized RWAs under the revised capital framework. • Generalized risk weights were imputed from FR Y-9C data. These weights were held fixed throughout the forecast horizon. Credit RWAs were calculated under the revised capital framework implementing the Basel III regulatory capital regime in the United States (standardized approach RWAs) from 2015q1 onwards. The weights used to calculate credit RWAs were held fixed throughout the planning horizon. Market RWAs were broken down into components that are cyclical and non-cyclical. The first group, which includes value at risk and the incremental risk charge, was projected based on the volatility of the trading portfolio of the BHCs. The second group, which includes value at risk, stressed value at risk, the specific risk charge, and the comprehensive risk charge, was assumed to evolve according to projections of the BHCs' trading	• 2015 switch to standardized approach to calculate RWAs was calibrated using Fed's estimate of RWAs using standardized approached and using generalized approach • Operational RWAs (for advanced approaches BHCs that exited the parallel run) were assumed to grow with total assets

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
			assets • Operational RWAs were not considered	
BANKING SECTOR: LIQUIDITY RISK				
1.Institutional Perimeter	Institutions included	• N.A.	• N.A.	• 31 largest BHCs
	Market share	• N.A.	• N.A.	• 75 percent
	Data and baseline date	• N.A.	• N.A.	• Publicly available data (FR Y-9C) • Consolidated banking group as of 2014Q3.
2. Channels of Risk Propagation	Methodology	• N.A.	• N.A.	• Liquidity metric was defined as the ratio of liquid assets over outflows using balances outstanding.
3. Tail shocks	Size of the shock	• N.A.	• N.A.	• Shocks reflected in Adjustment factors (haircuts and run-off rates) applied to high-quality liquid assets and outflows; Factor were informed historical dynamics of liquid assets and outflow categories
4.Risks and Buffers	Risks	• N.A.	• N.A.	• Funding liquidity risk • Market liquidity shock
	Buffers	• N.A.	• N.A.	• Liquid assets

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• N.A.	• N.A.	• Benchmark: haircuts calibrated based on the LCR; run-off rates calibrated based on the historical experience • Sensitivity analysis: run-off rates calibrated based on the LCR
	Regulatory standards	• N.A.	• N.A.	• Threshold set to 1.
BANKING SECTOR: SPILLOVER RISKS				
1.Institutional Perimeter	Institutions included	• N.A.	• N.A.	• 6 largest BHCs
	Market share	• N.A.	• N.A.	• 52 percent of BHCs' assets
	Data and baseline date	• N.A.	• N.A.	• 2014Q3
2. Channels of Risk Propagation	Methodology	• N.A.	• N.A.	• Espinosa and Sole (2013) network analysis
3. Tail shocks	Size of the shock	• N.A.	• N.A.	•
4. Risks	Risks	• N.A.	• N.A.	•
INSURANCE SECTOR: SOLVENCY RISKS				
1.Institutional Perimeter	Institutions included	• N.A.	• Full coverage of solo entities - 751 life insurers - 2,569 P&C insurers	• 43 Insurance groups, of which: - 20 life insurers - 16 P&C insurers - 5 health insurers

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
				- 2 credit insurers
	Market share	• N.A.	• 100 percent	• 40 percent (gross written premiums)
	Data	• N.A.	• Statutory accounting	• U.S. GAAP • Additional approach based on statutory accounting
	Baseline date	• N.A.	• End-2013	• End-2013
2. Channels of Risk Propagation	Methodology	• N.A.	• Investment assets: market value changes after price shocks, affecting the total adjusted capital (TAC) • In sensitivity analysis: Profitability negatively affected through prolonged period of interest rates: spread between net portfolio yields and guaranteed credited rates declining, ultimately resulting in weaker capital position	• Investment assets: market value changes after price shocks, affecting shareholder equity
	Stress test horizon	• N.A.	• Instantaneous shock (except for "low-for-long" analysis: 5 years, i.e. 2014-2018)	• Instantaneous shock (except for "low-for-long" analysis: 5 years, i.e. 2014-2018)
3. Tail shocks	Sensitivity analysis	• N.A.	• Natural catastrophes: - Florida hurricane (similar to but worse than "Andrew", 1992) - California earthquake (similar to but worse than "Northridge" event, 1994) - Series of tornados (three tornados, classified as EF5, in	• Natural catastrophes: - Hurricane (similar to but worse than "Andrew", 1992) - Earthquake (similar to but worse than "Northridge" event, 1994) - Series of tornados (three tornados, classified as EF5, in

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
			the Midwest of the United States) • Prolonged period of low interest rates ("low-for-long"): assuming unchanged level of interest rates until 2018	- the Midwest of the United States) • Pandemic • Prolonged period of low interest rates ("low-for-long"): assuming unchanged level of interest rates until 2018
4.Risks and Buffers	Risks/factors assessed	• N.A.	• Market value shocks: - Sovereign bonds: +2% - Municipal bonds: -5% - CMBS and RMBS: between -5% and -28% - Mortgage loans: -5% - Equity: -40% for unaffiliated, -30% for affiliated, -10% for preferred - Property: -30% - Other investment assets: -30% • Potential loss from guarantees in variable annuities: 10% of the maximum guaranteed amount • Catastrophic risk: 1-in-250 year event for the Florida hurricane and the California earthquake	• Market value shocks: - CMBS, RMBS and other ABS: between -28.7% and -51.3% - Mortgage loans: -12.2% - Equity: -28.9% - Property: -28.3% - Other investment assets: -28.9% • Credit spread shocks: - U.S. sov. bonds: +58.4bp - Municipal bonds: between +66.0bp (AAA-A) and +429.0bp (BB) - Other sov. bonds: between +56.7bp (AAA-A) and +1,661bp (CC and lower) - Corporate bonds: between +248.1bp (AAA-A) and +1,878bp (CC or lower) • Shock to the USD risk-free interest rate: between -21bp for 1 year and -143bp for 30 years

Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
				• Catastrophic risk: 1-in-250 year event for the Florida hurricane and the California earthquake • Pandemic: higher mortality rate: +1.5 additional deaths per 1,000
	Risk aggregation	• N.A.	• Sum of individual shocks	• Sum of individual shocks
	Buffers	• N.A.	• Coverage of risk-based capital (RBC)	• Shareholder equity
	Behavioral adjustments	• N.A.	• None	• None
ASSET MANAGERS: LIQUIDITY RISKS				
1.Institutional Perimeter	Institutions included	• N.A.	• N.A.	• Largest mutual funds (9.000 mutual funds) divided into different styles of mutual funds
	Data and baseline date	• N.A.	• N.A.	• 2014Q3
2. Channels of Risk Propagation	Methodology	• N.A.	• N.A.	• Comparing redemptions with capacity of market for a particular asset class to be sold in an orderly manner (securities of mutual funds mapped into portfolio categories of NY Federal data on dealers' inventory) • Assuming a ranking of assets to be sold to meet redemptions • Redemptions applied to individual mutual funds of the

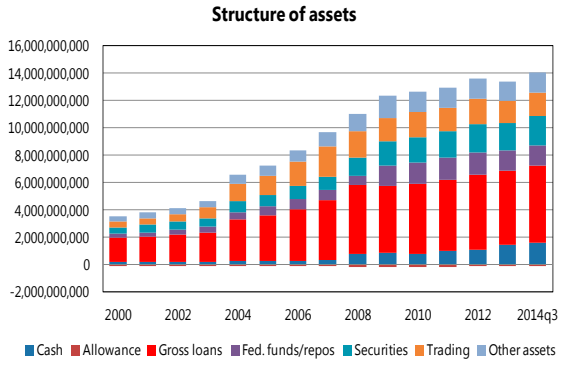
Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
				same style; redemptions calculated by style of mutual fund as an average redemption rate across all mutual funds of the same style; shock: 1st percentile of redemption rates' distribution • For MMFs: an approximation of the LCR calculated
	Stress test horizon	• N.A.	• N.A.	• One quarter (shock characterized by a run on a fund represented by an assumed redemption rate)
3. Tail shocks	Sensitivity analysis	• N.A.	• N.A.	• N.A.
4.Risks and Buffers	Risks	• N.A.	• N.A.	• Liquidity risk (a run on a mutual fund)
	Buffers	• N.A.	• N.A.	• Liquid assets • Capacity of a particular market to absorb sell-off of corresponding asset to meet redemptions (by comparing mutual fund's portfolio of a particular security with dealers' inventory of the same security)
MARKET-PRICE BASED: CREDIT/DEFAULT RISKS AND CROSS-BORDER SPILLOVER RISKS				
1.Institutional Perimeter	Institutions included	• N.A.	• N.A.	• 210 institutions with publicly traded equity (divided into 7 different sectors, five domestic financial and non-financial

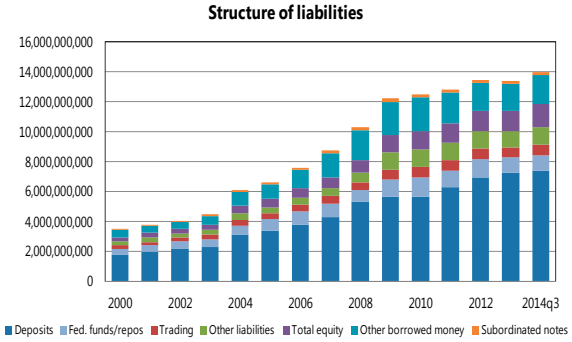
Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
				sectors and two foreign financial sectors) • 178 institutions are domiciled in the U.S. and 32 are domiciled in non-U.S. jurisdictions • Domestic sectors include U.S. banks, insurers, non-financial corporates, asset managers, and other non-bank financial institutions • Foreign sectors include foreign banks (non-U.S. GIBs) and foreign insurers (non-U.S. G-SIIs and other large non-U.S. insurers)
	Market Share			• U.S. Banks and insurers (75 percent or greater of total sector assets) • U.S. corporates, asset managers, and other-non bank financial institutions (40% or greater of total sector assets) • Foreign banks and insurers (100% of GSIB and G-SII total assets)
	Data and baseline date			• All data from end 2004Q3 to 2014Q3 • Credit risk data from CreditEdge • Macro data from Haver and Datastream • Connectivity data computed by

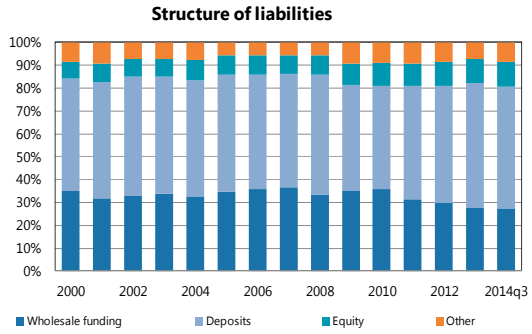
Domain		Assumptions		
		Bottom-Up by Financial Institutions	**Top-Down by Authorities**	**Top-down by FSAP Team**
				IMF using CreditEdge data • Non-daily data temporally disaggregated to daily frequency using Chow-Lin Max-Log methodology
2. Channels of Risk Propagation	Methodology			• Contingent Claims Analysis • General Adaptive Models of Location, Scale, and Shape (GAMLSS)
3. Tail shocks	Size of the shock			• DFA/IMF stress and baseline macroeconomic scenarios • One time 50 basis point shock to counter-party sector default probabilities
4. Risks	Risks			• Macro risks • Interconnectivity risk • Cross-border and domestic spillover risk • Credit risk • Default risk

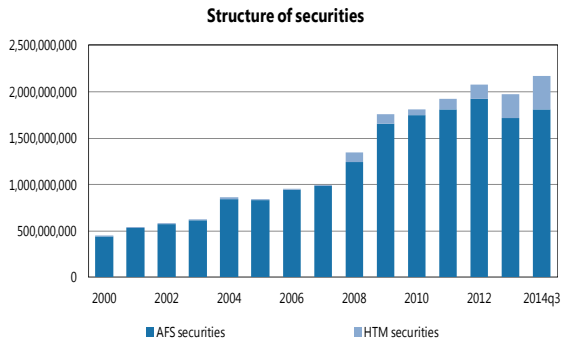
Appendix II. Additional Data: Banking Sector

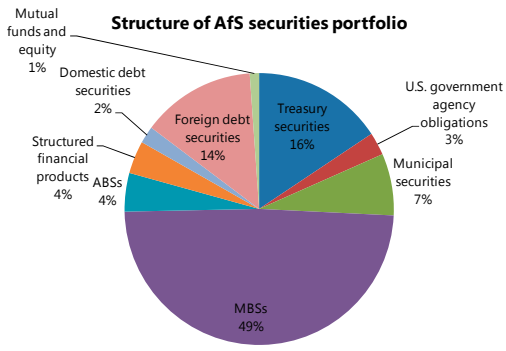
Appendix Figure 1. Developments in the Banking Sector

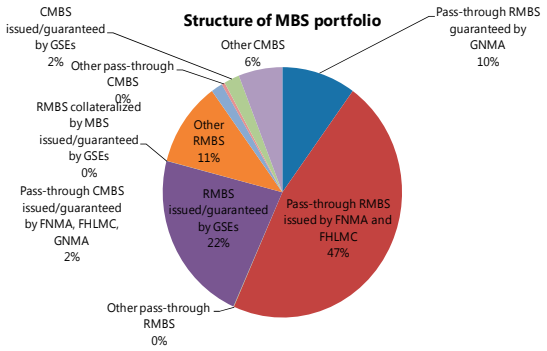




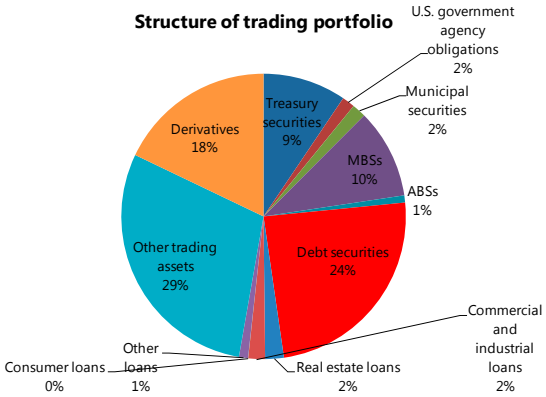


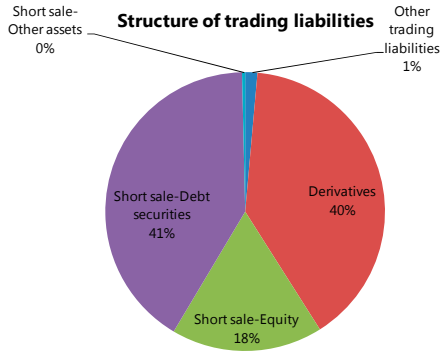


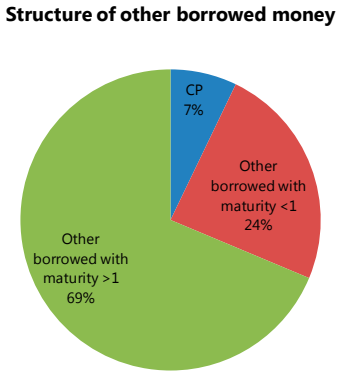


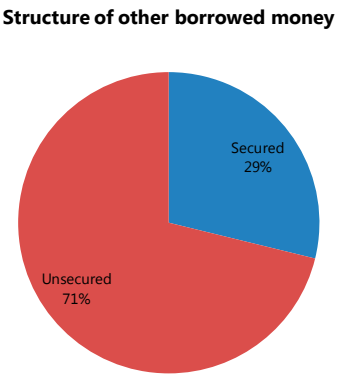


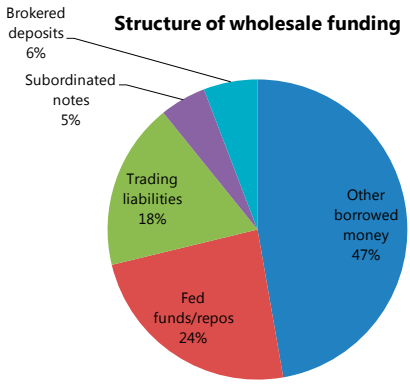
Appendix Figure 1. Developments in the Banking Sector (continued)

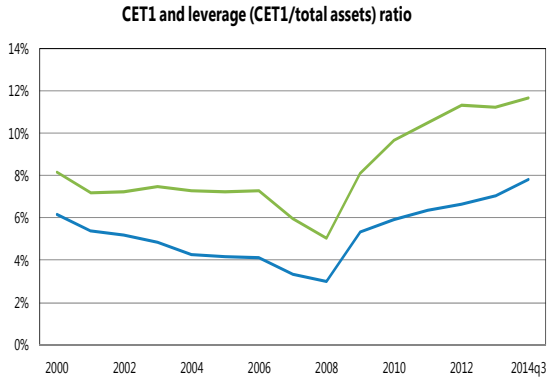




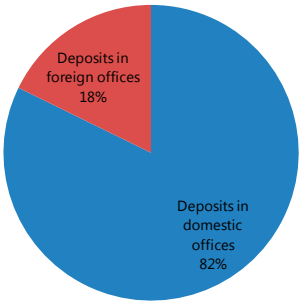


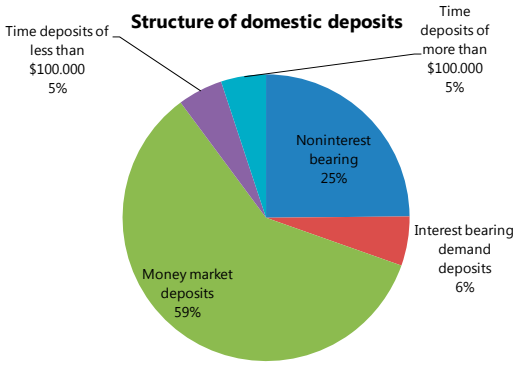


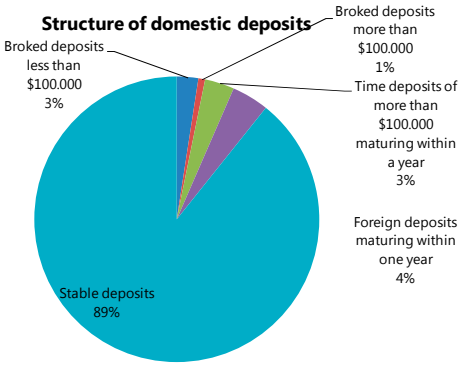


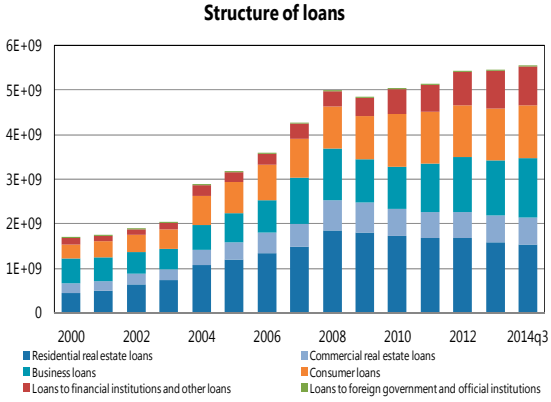


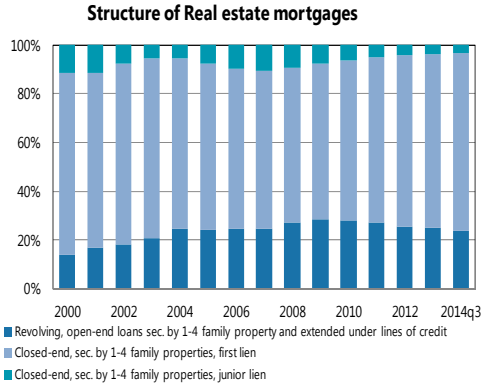
Appendix Figure 1. Developments in the Banking Sector (continued)

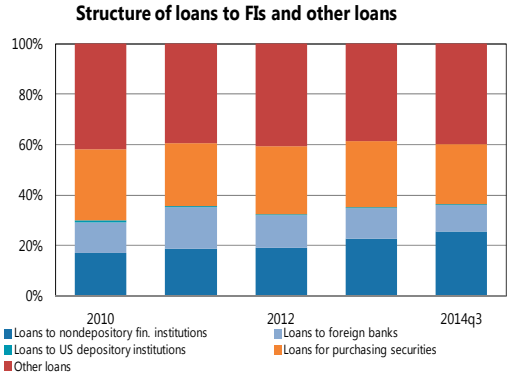






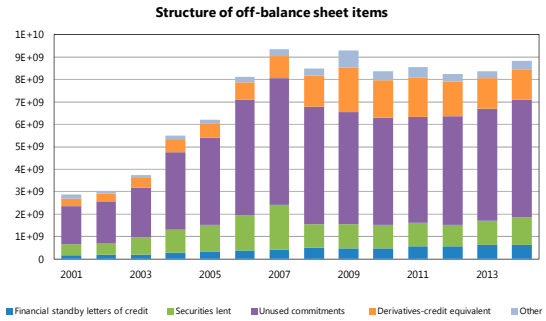


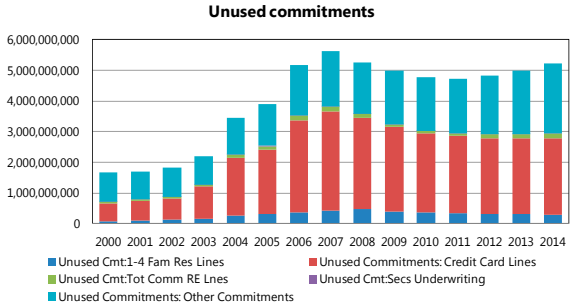


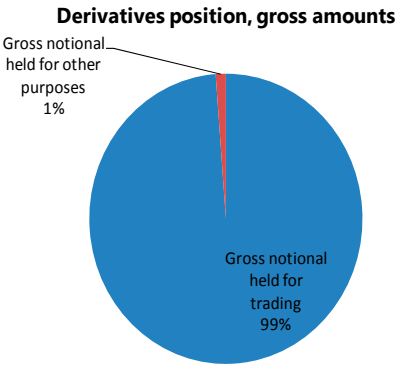


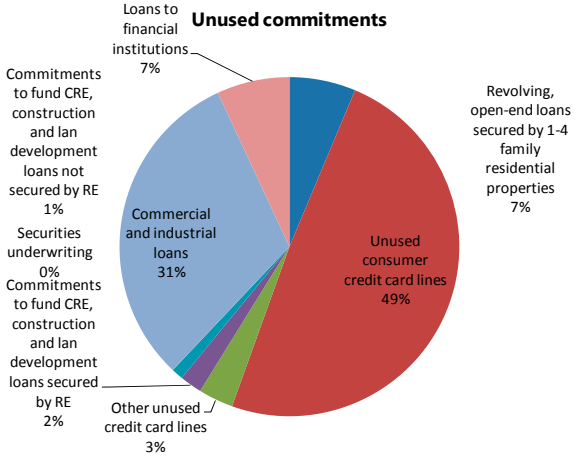
Appendix Figure 1. Developments in the Banking Sector (continued)

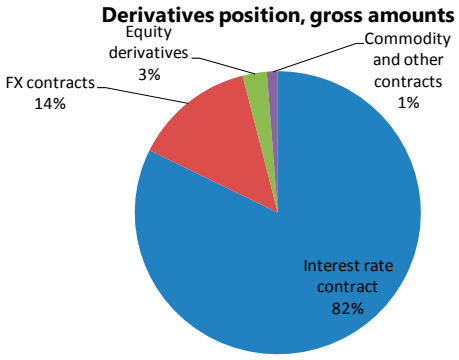
Appendix Figure 1. Developments in the Banking Sector (continued)

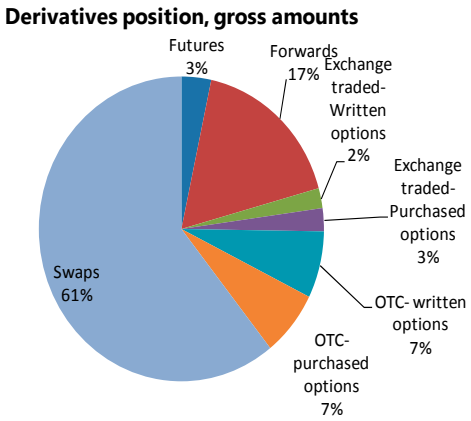






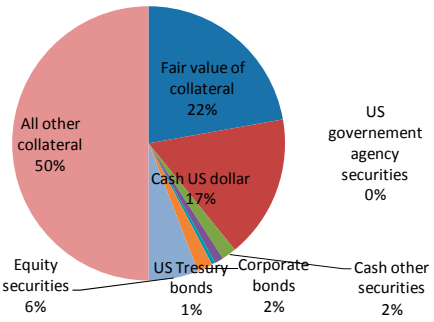




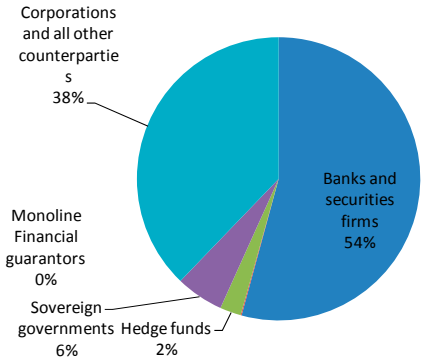


Appendix Figure 1. Developments in the Banking Sector (continued)

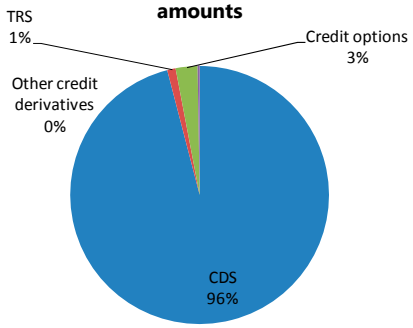
OTC derivatives, collateral



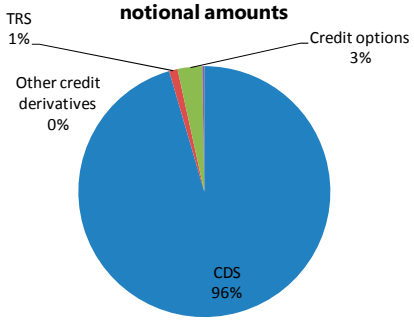
OTC derivatives, counterparties



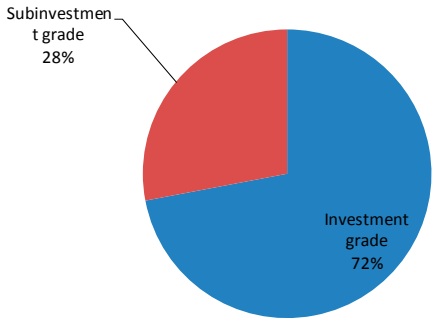
Credit derivatives, sold protection, notional amounts



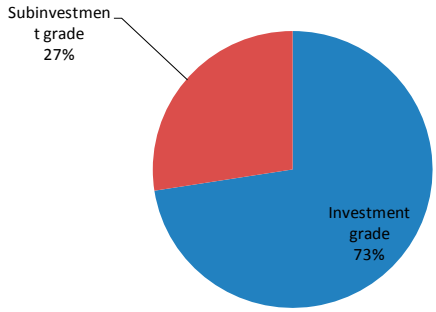
Credit derivatives, purchased protection, notional amounts



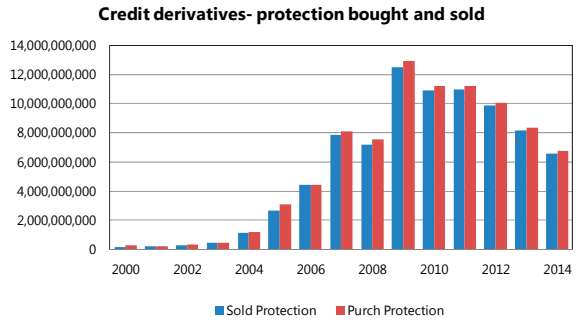
Credit derivatives, sold protection

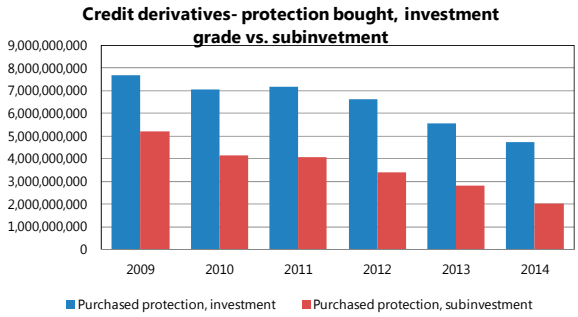


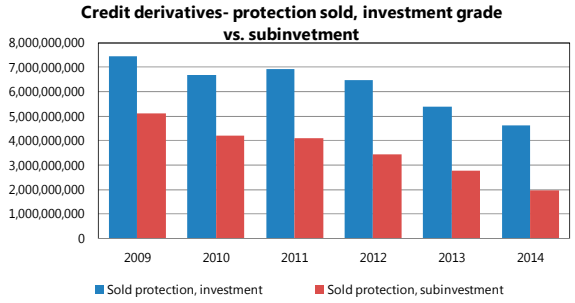
Credit derivatives, purchased protection



Appendix Figure 1. Developments in the Banking Sector (continued)

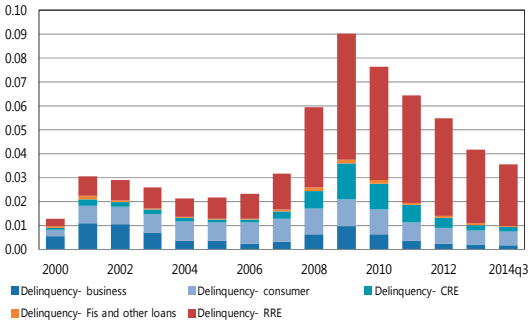




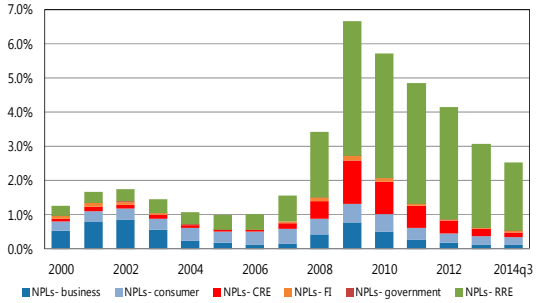


Appendix Figure 1. Developments in the Banking Sector (continued)

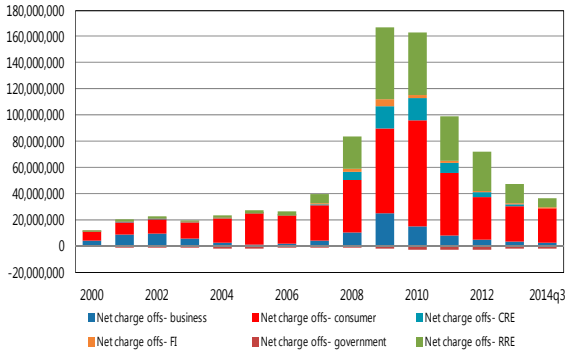
Deliquencies (as % of total net loans)



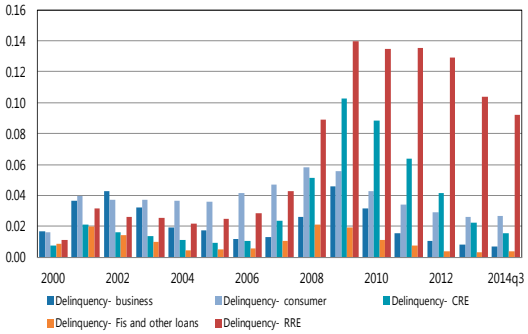
NPLs (as % of total net loans)



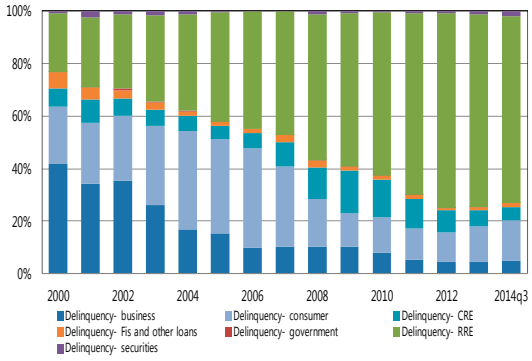
Net charge offs



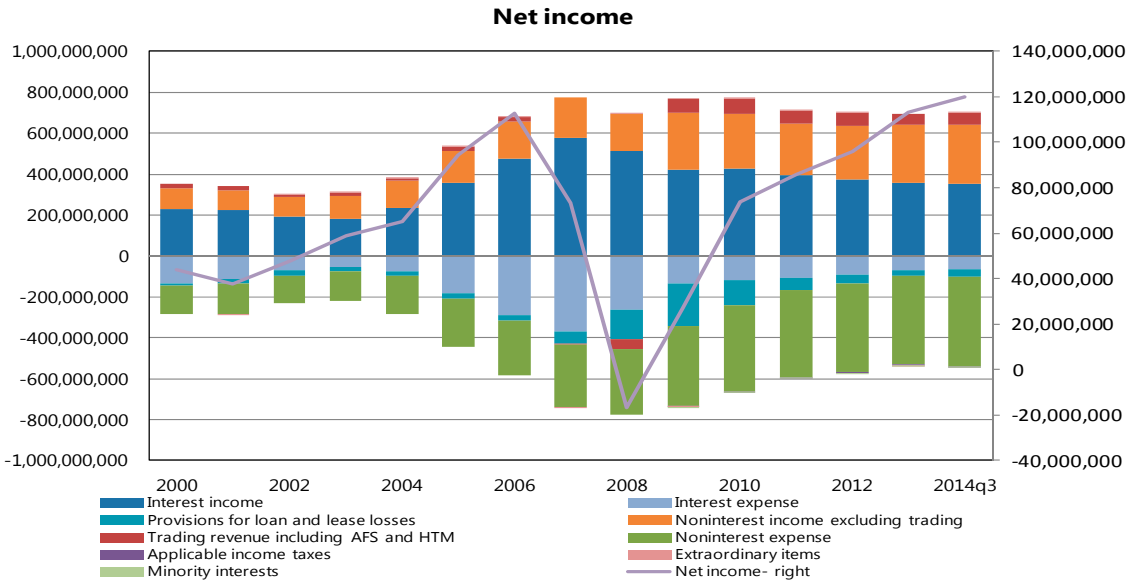
Deliquencies (as % of corresponding loan type)

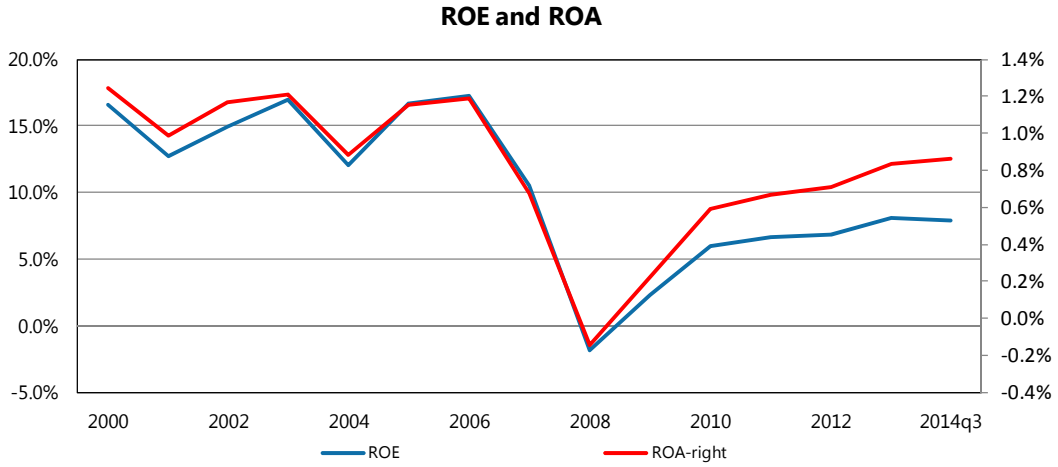


Structure of deliquencies



Appendix Figure 1. Developments in the Banking Sector (continued)

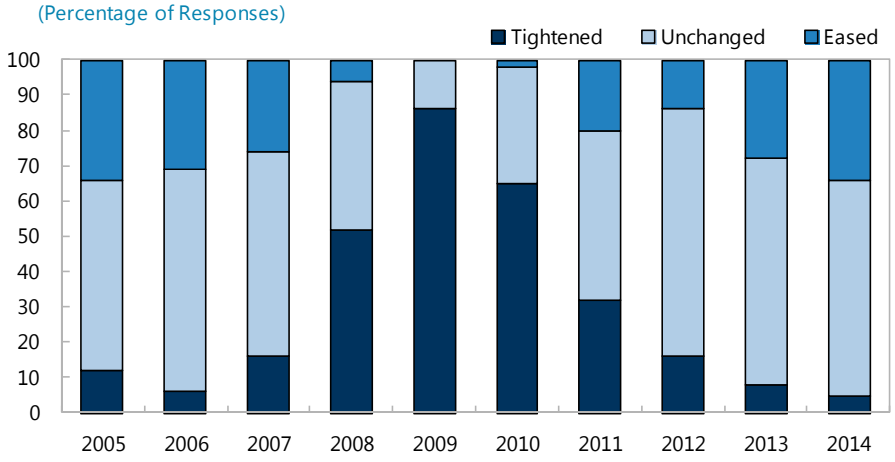




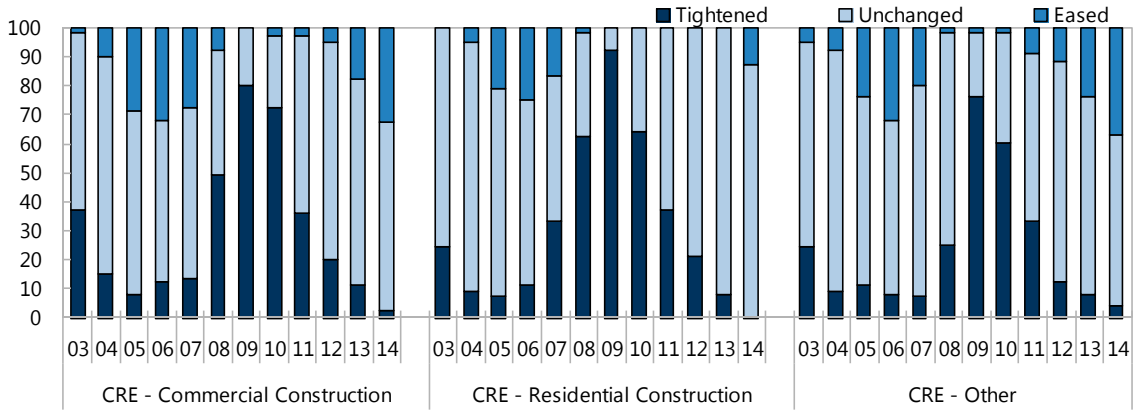
Source: FRB, SNL, IMF Staff calculations

Appendix Figure 2. Underwriting Standards

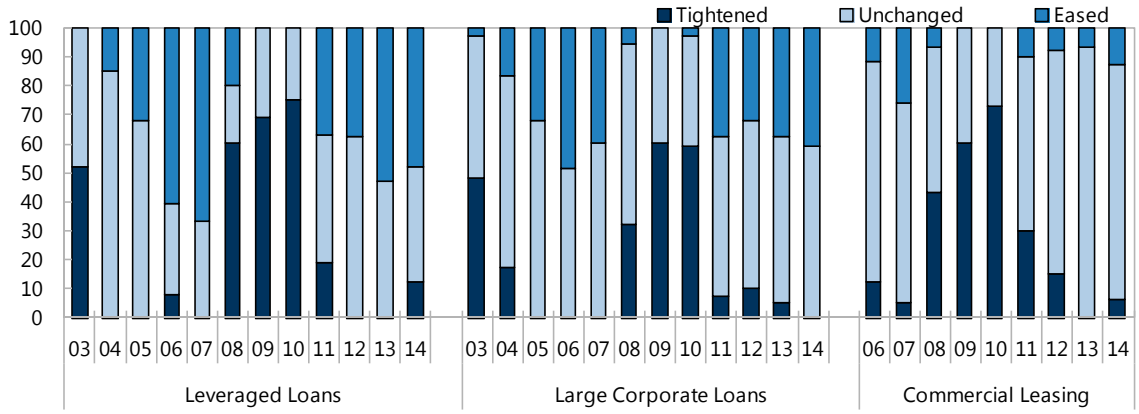
Overall Commercial Credit Underwriting Trends
(Percentage of Responses)



Commercial Underwriting Trends, by Product Type

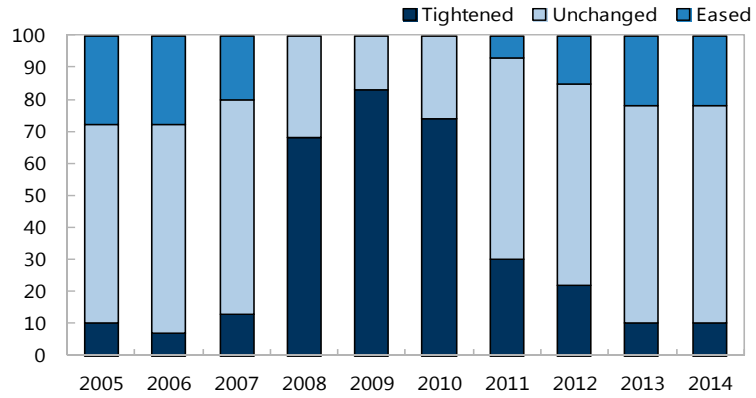


Commercial Underwriting Trends, by Product Type

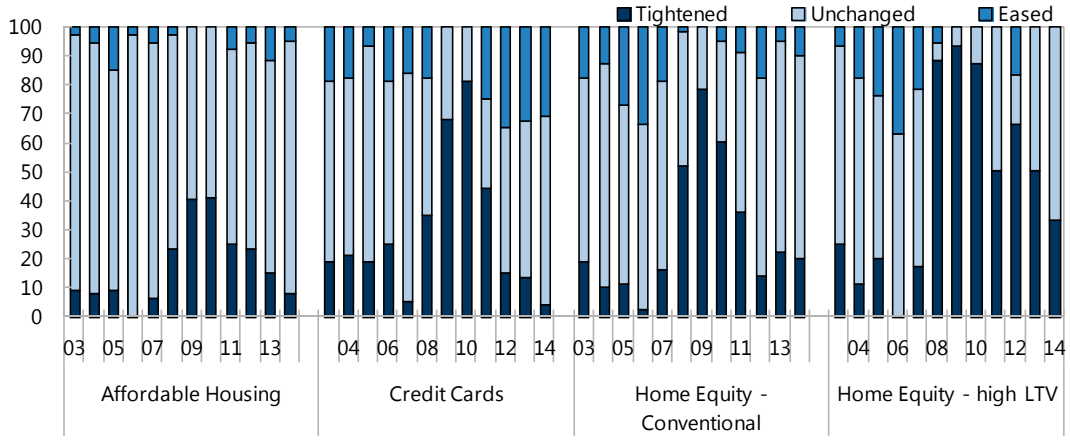


Appendix Figure 2. Underwriting Standards (continued)

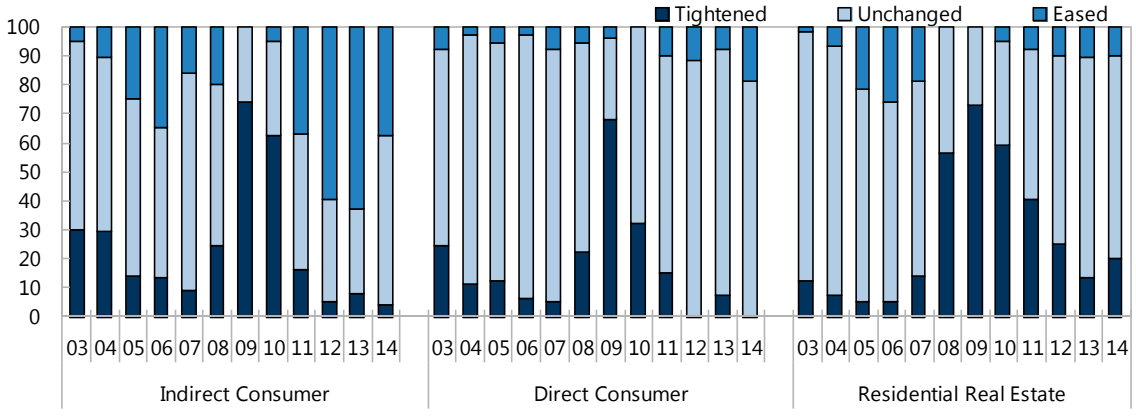
Overall Credit Underwriting Trends - Retail



Retail Underwriting Trends, by Product Type

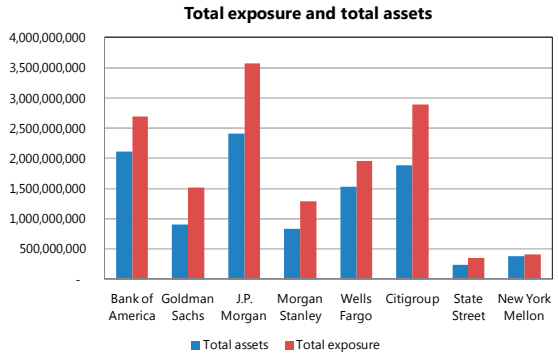


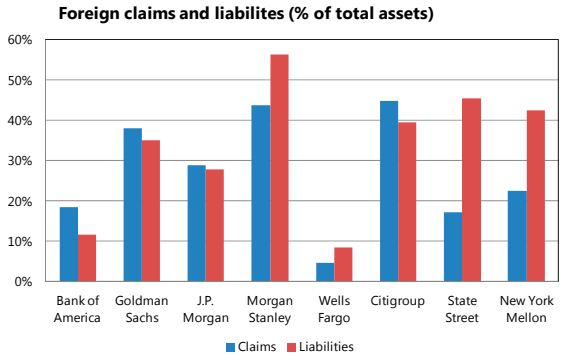
Retail Underwriting Trends, by Product Type

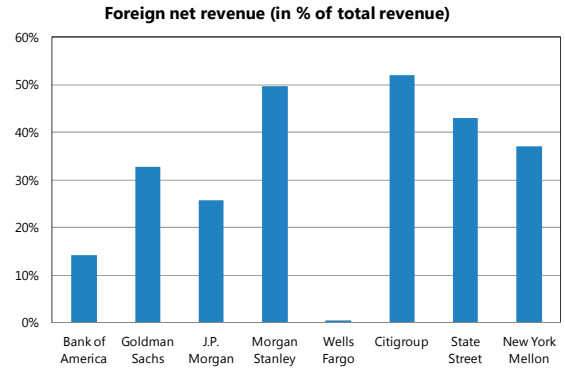


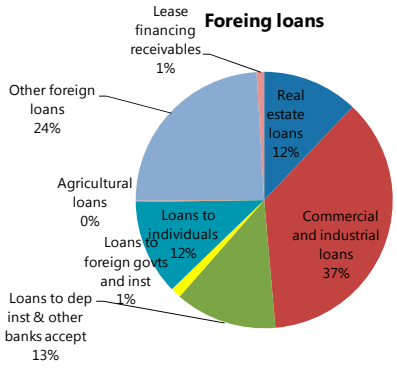
Source: OCC

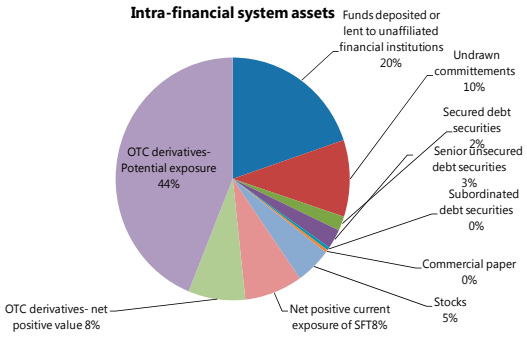
Appendix Figure 3. GSIBs

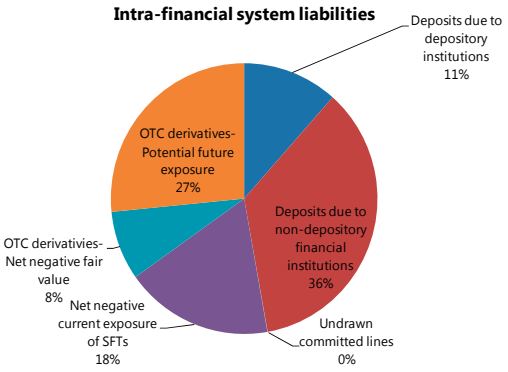




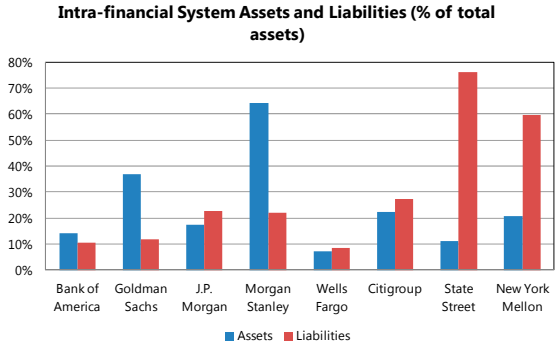


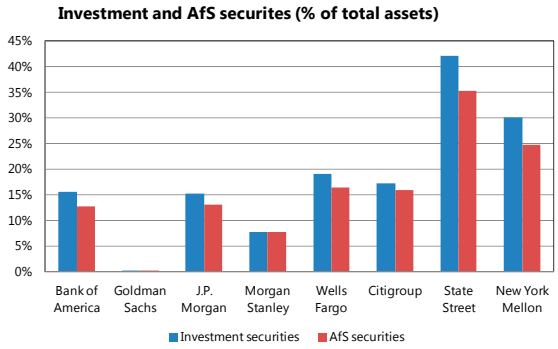


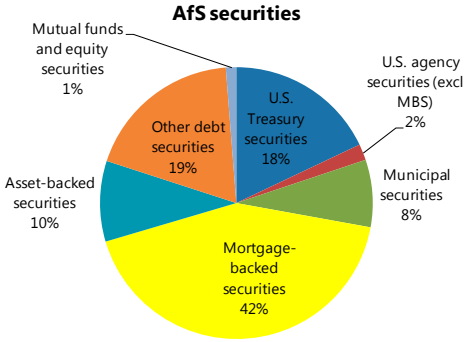


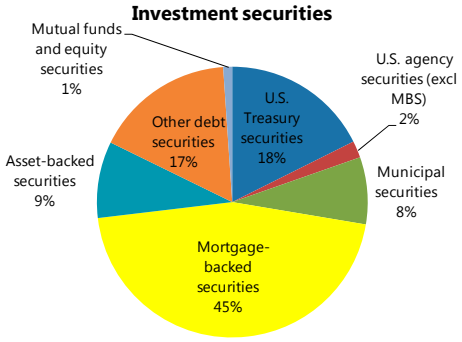


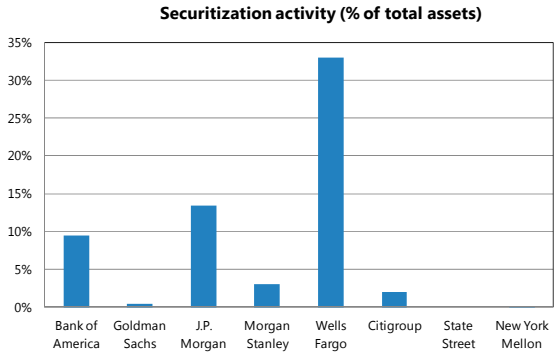
Appendix Figure 3. GSIBs (continued)

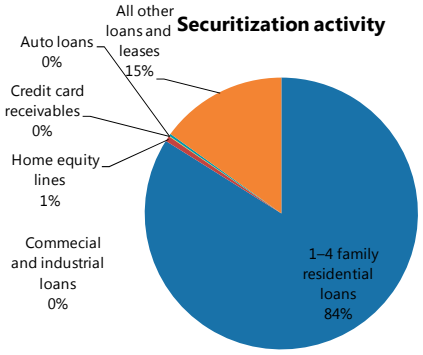




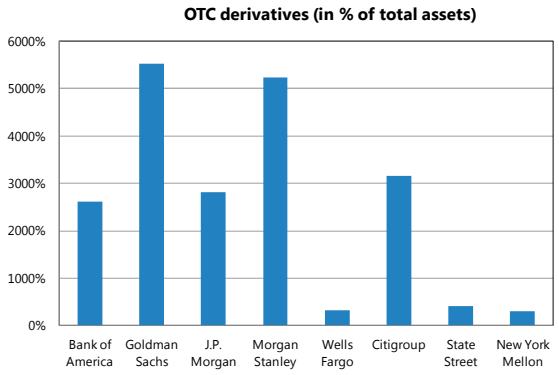


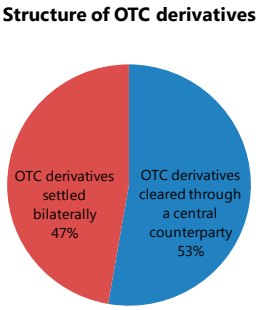


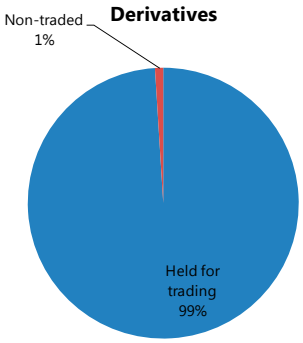


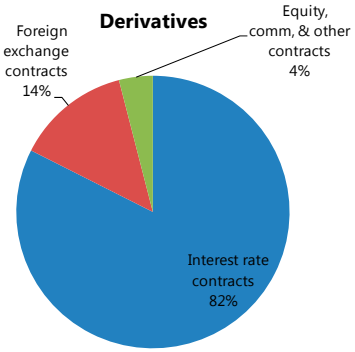


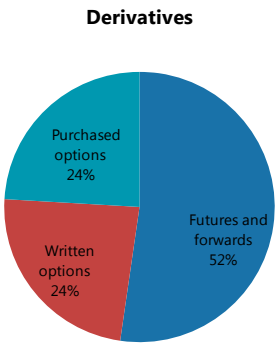
Appendix Figure 3. GSIBs (continued)

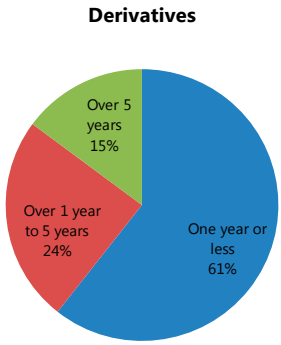








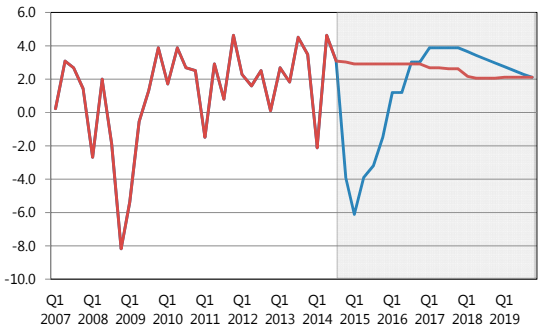




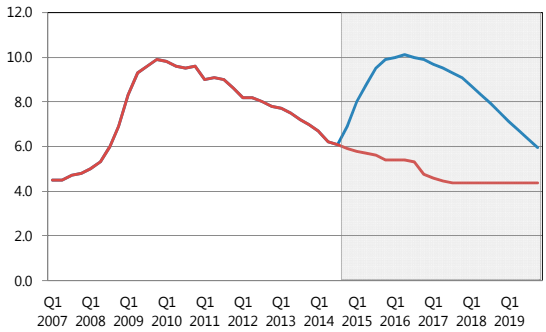
Source: FRB, SNL, IMF Staff calculations

Appendix Figure 4. Macroeconomic Scenarios: Main Variables

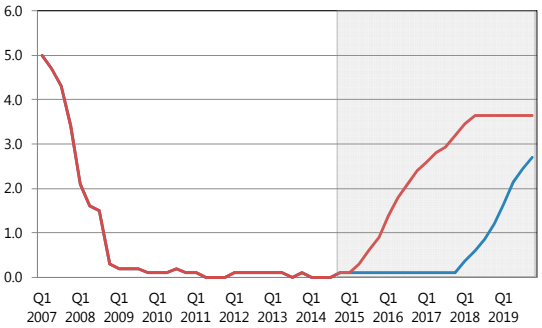
GDP growth, q-o-q, annualized, in %



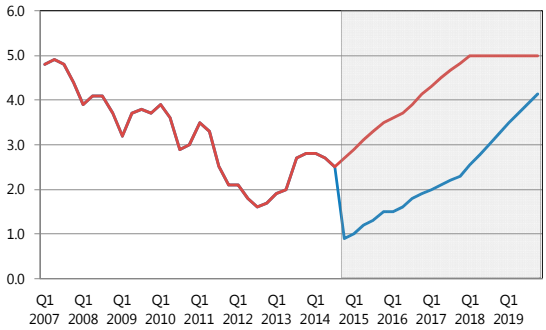
Unemployment rate, in %



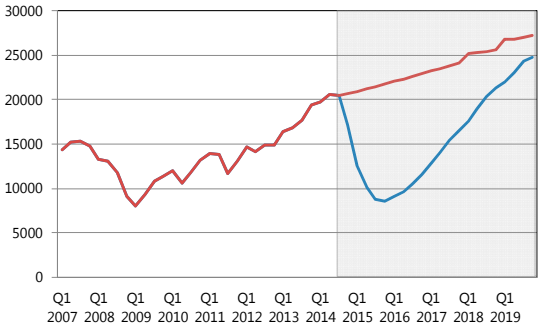
3-month Treasury yield, in %



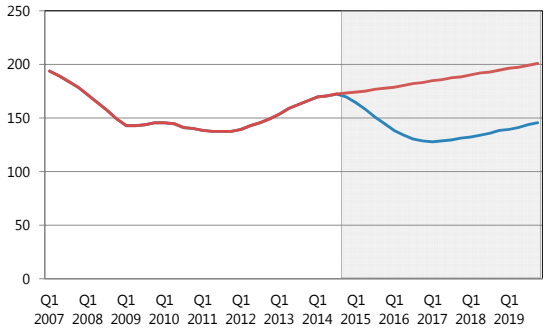
10-year Treasury bond yield, in %



Dow Jones Industrial Stock Market Index

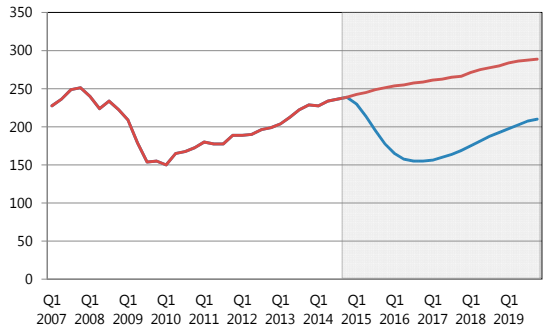


House price index

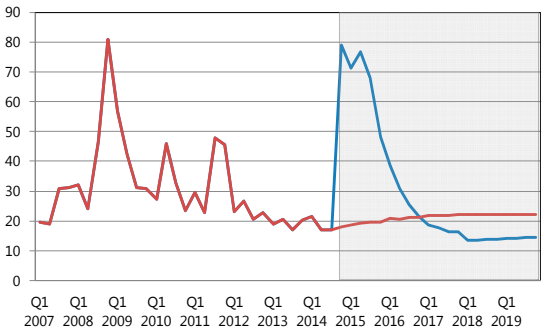


Appendix Figure 4. Macroeconomic Scenarios: Main Variables (continued)

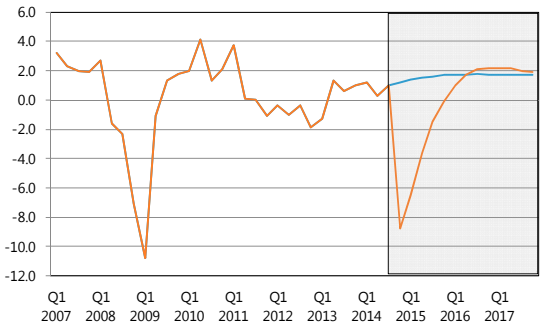
Commercial Real Estate Price Index



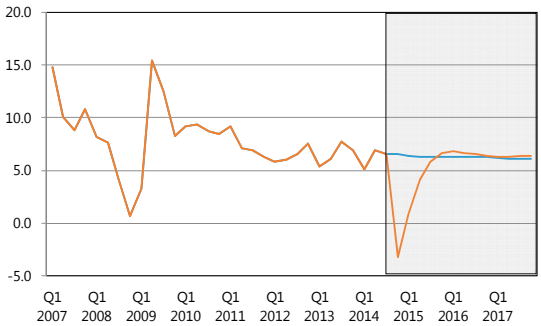
Market volatility index



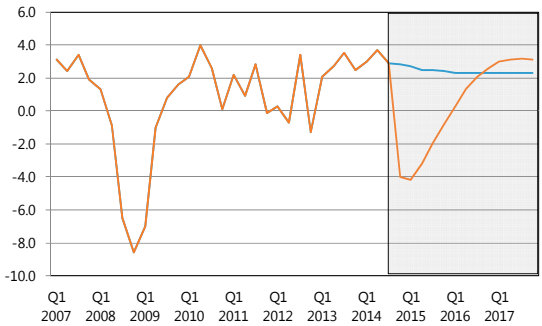
Euro area GDP growth



Developing Asia real GDP, q-o-q rate, %



UK GDP growth



Source: FRB, IMF Staff calculations

Appendix Table 3. Estimation Results: Income Statement Items

	Net interest income	Non-interest income excluding	Trading income	Non-interest expense	AOCI	Provisions	Provisions
Dependent variable specification	d^4	Share in total assets	Share in total assets	y/y	Share in total assets	Share in total net loans	Share in total net loans
Panel/Aggregate	Panel	Panel	Aggregate	Panel	Aggregate	Aggregate	Panel
Lag of dependent variable	No	No	No	No	No	No	No
d^4(Loans x Lending rate)	0.001775***						
d^4(Deposits x Depoit rate)	-0.001586***						
Total assets, y/y				0.856675***			
Lending rate		-0.000118***					0.000133***
Real GDP, y/y					0.000260***	-0.000323***	-0.000194***
Real GDP, y/y x Dum (=1 if y/y<0)					0.000682***		
Unemployment rate		-0.000408***					
d(Unemployment rate)							0.001762***
d^4(Unemployment rate)						0.001174***	
d^4(10-year Treasury yield)					-0.000512***		
d(10-year Treasury yield - 3 month			0.000773***				
d^4(BBB corporate yield)					-0.000112		
BBB corporate yield - 3-month rate			-0.000819***			0.000130	0.000336***
Mortgage rate							
House Price Index (y/y)						-6.85E-05***	-8.70E-05***
Market Volatility Index, y/y		-0.00000313***	0.00000884***			-6.58E-06	
Market Volatility Index, y/y x Dum(=1 if y/y>0)			-1.76E-05***			1.90E-05**	
Market Volatility Index, level							1.77E-05***
Constant	26819.86***	0.009149***	0.001206***	2.369656***	-0.001447***		0.000369
R^2	0.53	0.81	0.41	0.39	0.54	0.84	0.56
Number of observations	2231	2287	95	2232	97	95	2237

Source: IMF Staff calculations

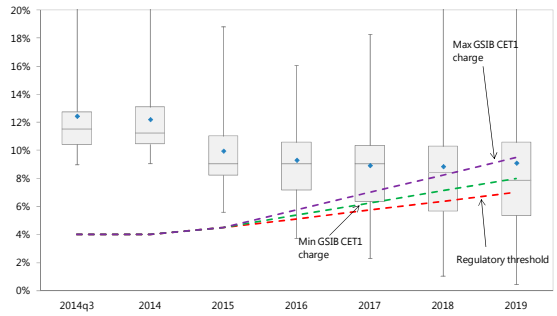
Appendix Table 4. Estimation Results: Balance Sheet Items, Net Charge offs, RWAs

	Net loans	Total assets	RWAs	NCOs bussiness loans	NCOs consumer loans	NCOs RRE loans	NCOs CRE loans	NCOs financial institutions loans	NCOs total
Dependent variable specification	y/y	y/y	y/y	Share in loans	Share in loans	Share in loans	Share in loans	Share in loans	Share in loans
Panel/Aggregate	Panel	Panel	Panel	Panel	Panel	Panel	Panel	Panel	Panel
Lag of dependent variable	Yes	No	No	No	No	No	No	No	No
Net loans, y/y	0.346118***	0.793545***							
Total assets, y/y			0.899295***						
Lending rate			0.907326***						0.00002
d^4(Lending rate)	-2.299608***								
Real GDP, y/y	1.45978***					-0.00007**	-0.000123**	-0.000467***	-0.000242***
Real GDP, y/y x Dum (=1 if y/y<0)									
Unemployment rate						0.000688***	0.001498***		
d(Unemployment rate)									0.00006
d^4(Unemployment rate)				0.001008***	0.000851***				
BBB corporate yield - 3-month rate				0.000178***					0.000271***
d^4(Mortgage rate)						0.000247***			
House Price Index (y/y)					-0.000114***	-0.00004***			-0.00008***
Commercial Real Estate Price Index (y/y)							-0.00004***		
Market Volatility Index, level	-0.070382***			0.00001		0.00003***	0.00004***	0.00007***	0.00001**
Business interest rates							0.000508***		
d^4(Consumer interest rates)					0.000598***				
d^4(Federal funds rate)								0.000187	
Constant	2.808341***	2.584347***	-4.794070***	0.000981***	0.004841***	-0.003267***	-0.011038	0.000731	0.001724***
R^2	0.39	0.76	0.84	0.37	0.56	0.46	0.28	0.08	0.56
Number of observations	2088	2253	1769	2179	2199	2166	2199	2287	2172

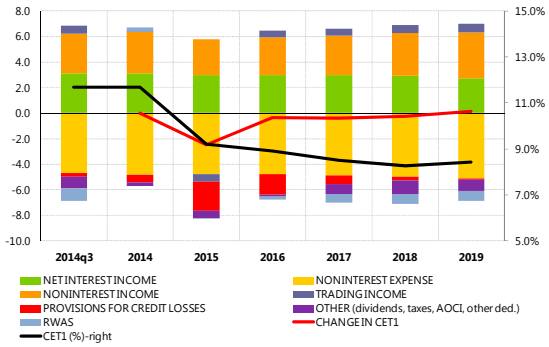
Source: IMF Staff calculations

Appendix Figure 5. Banking Stress Test Results: IMF Top-Down

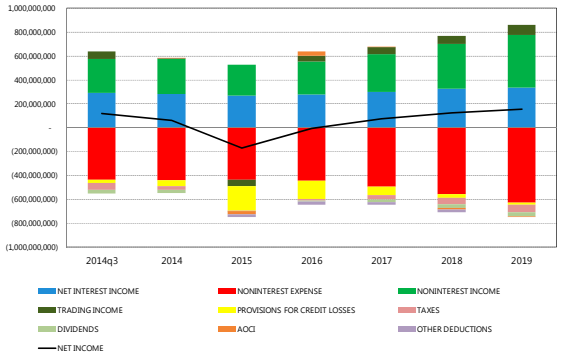
CET1 ratio



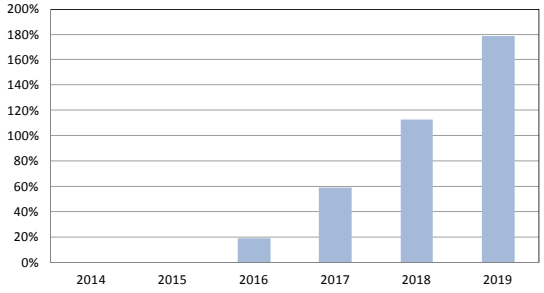
Contributions to CET1 ratio



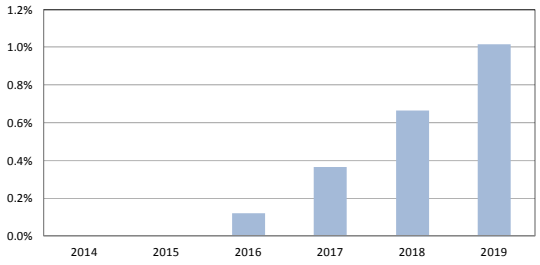
Net income over the stress horizon



Recapitalization needs (share of 2014 net income)



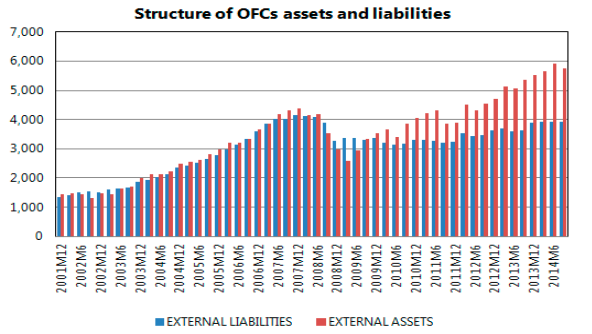
Recapitalization needs (share of nominal GDP)

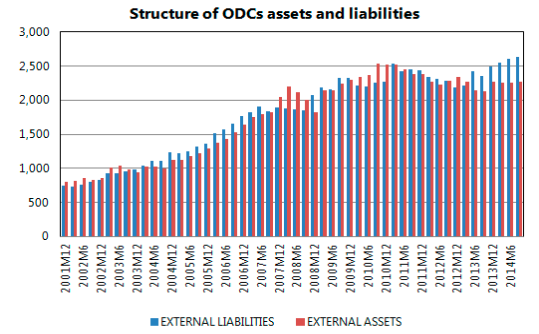


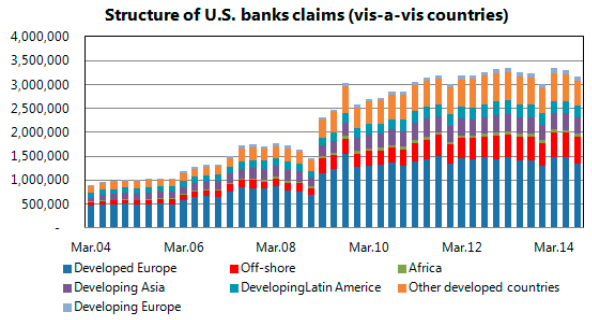
Source: IMF Staff calculations

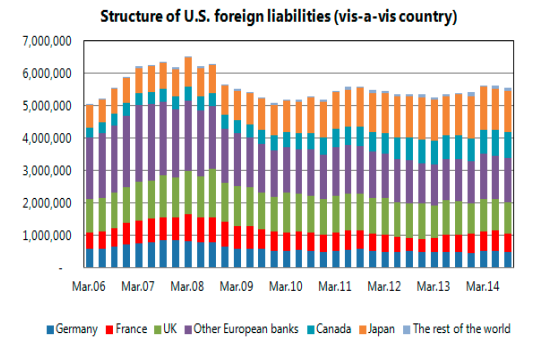
Appendix Figure 6. U.S. Cross-Border Assets, Liabilities, and Flows

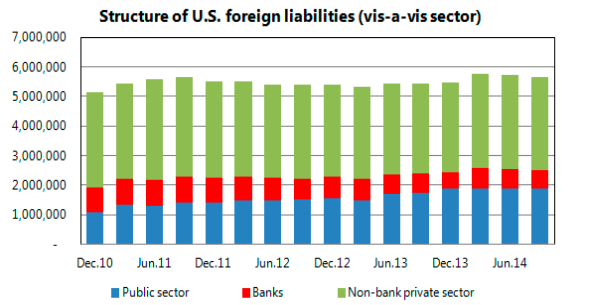
(Billions US$)

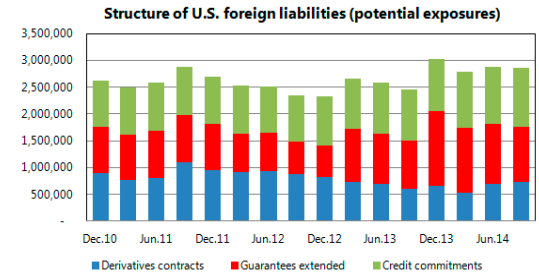


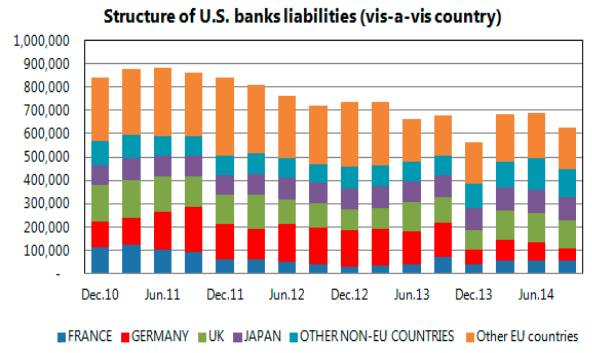


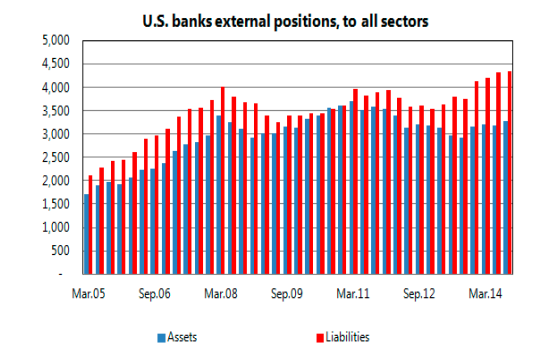








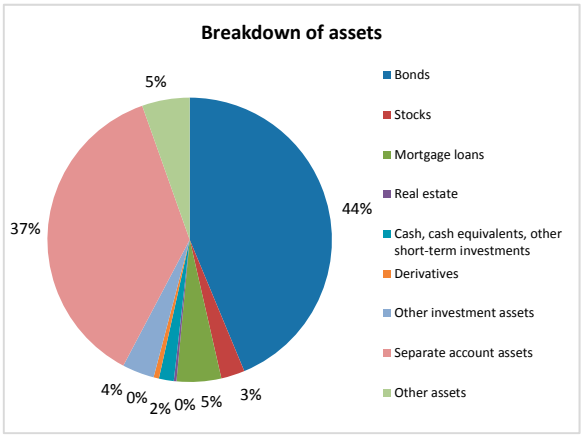


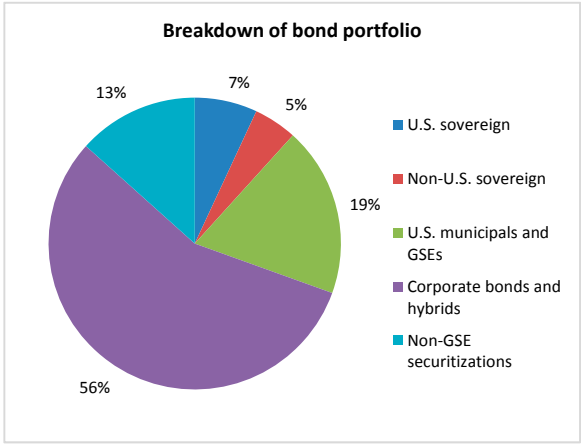


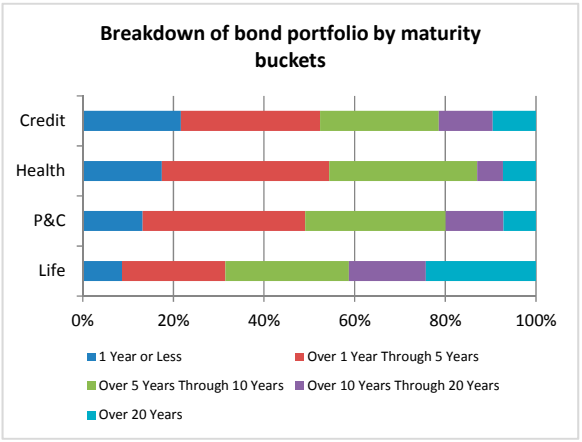
Source: IMF, BIS, IMF staff calculations

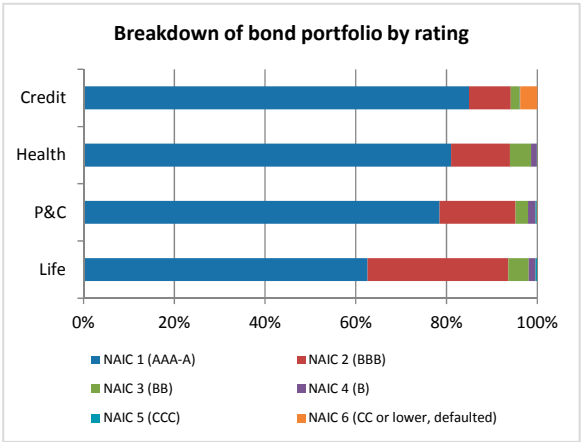
Appendix III. Additional Data: Insurance Sector

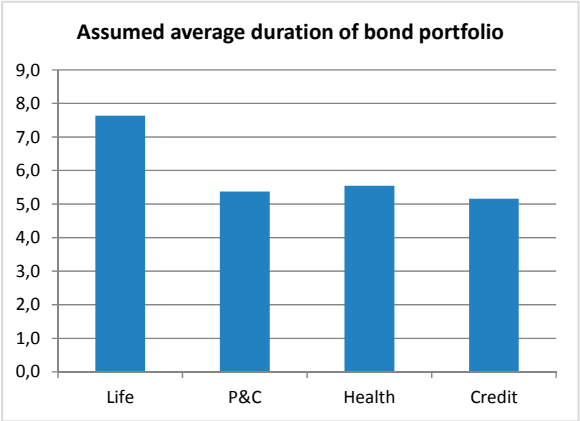
Appendix Figure 7. Insurance Assets











Source: SNL Financial and IMF staff calculations

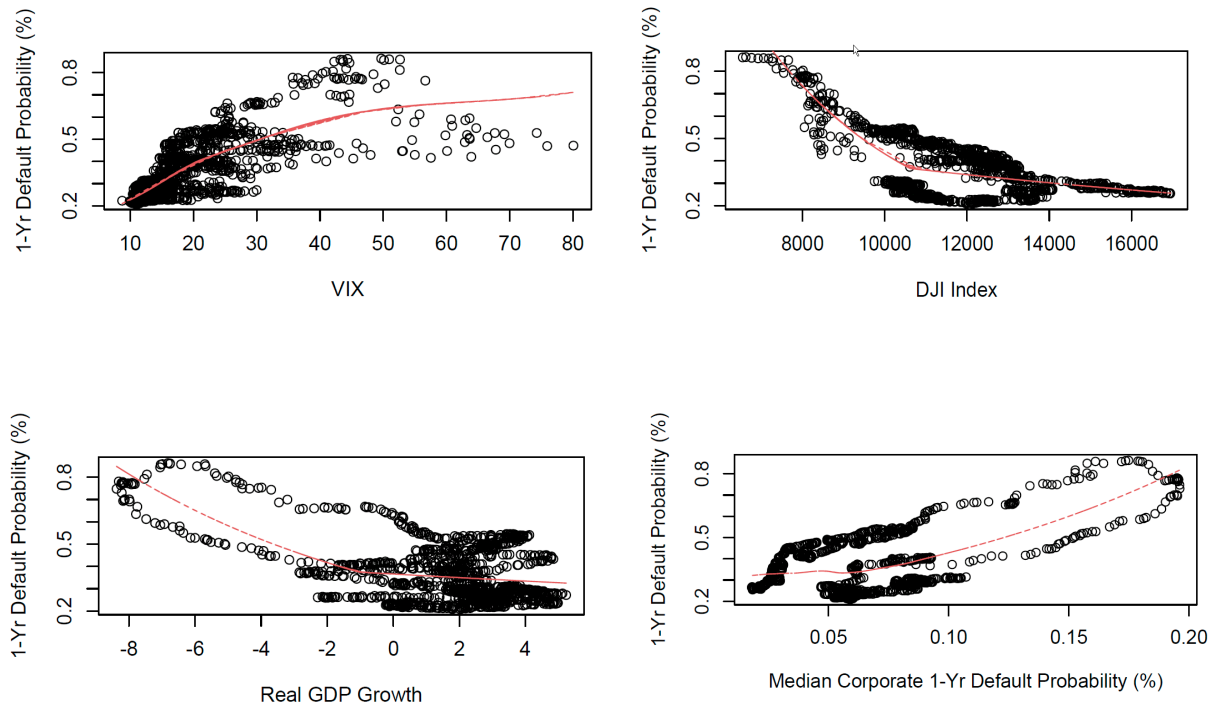
Appendix IV. Additional Results: Market-Based Tests

Appendix Table 5. GAMLSS Overall U.S. Financial System Model				
Variable name	**Additive term structure**	**Coefficient estimate**	**P-value**	
Intercept term		-5.55E+00	< 2e-16	***
5-year treasury yield		-4.21E-02	< 2e-16	***
Dow Jones stock market index	free knot	N/A; fully non-parametric; see term plot (Figure I)		
VIX	localized regression (LOESS)	N/A; fully non-parametric; see term plot (Figure I)		
House price index		-1.56E-03	< 2e-16	***
CRE price index		-2.00E-03	< 2e-16	***
USD/euro exchange rate		-2.59E-03	< 2e-16	***
BBB corporate yield		5.41E-02	< 2e-16	***
Real GDP growth rate	free knot	N/A; fully non-parametric; see term plot (Figure I)		
Euro area inflation	varying coefficient	1.00E-02	1.57e-07	***
Median 1-year default probability for Asset Manager sector		6.14E+01	< 2e-16	***
Median 1-year default probability for Bank sector		3.71E+01	< 2e-16	***
Median 1-year default probability for Insurer sector		1.29E+01	4.58e-07	***
Median 1-year default probability for NBFI sector		9.79E+00	3.83e-13	***
Median 1-year default probability for Corporate sector	localized regression (LOESS)	N/A; fully non-parametric; see term plot (Figure I)		
Median 1-year default probability for Foreign Bank sector		3.37E+00	2.74e-11	***
Median 1-year default probability for Foreign Insurer sector		3.196E-00	0.000129	***
Global clustering coefficient score	first order orthogonal polynomial	1.89E+00	< 2e-16	***
Global clustering coefficient score	second order orthogonal polynomial	-3.77E-01	< 2e-16	***
Global clustering coefficient score	third order orthogonal polynomial	2.17E-01	< 2e-16	***
Significance codes: 0 *, 0.001**, 0.01*, 0.05'', 0.1'''**				
Number of observations in the fit:	1244			
Degrees of Freedom for the fit:	44.94656			
Residual Degrees of Freedom:	1199.053			
Global Deviance:	-20500.05			
AIC:	-20410.15			

SBC:	-20279.75			
Distribution type:	Inverse Gaussian			
Link function for the mean:	Log			
Generalized R-squared:	0.9965047			
Dependent variable:	Median 1-year default probability for Overall U.S. Financial System			

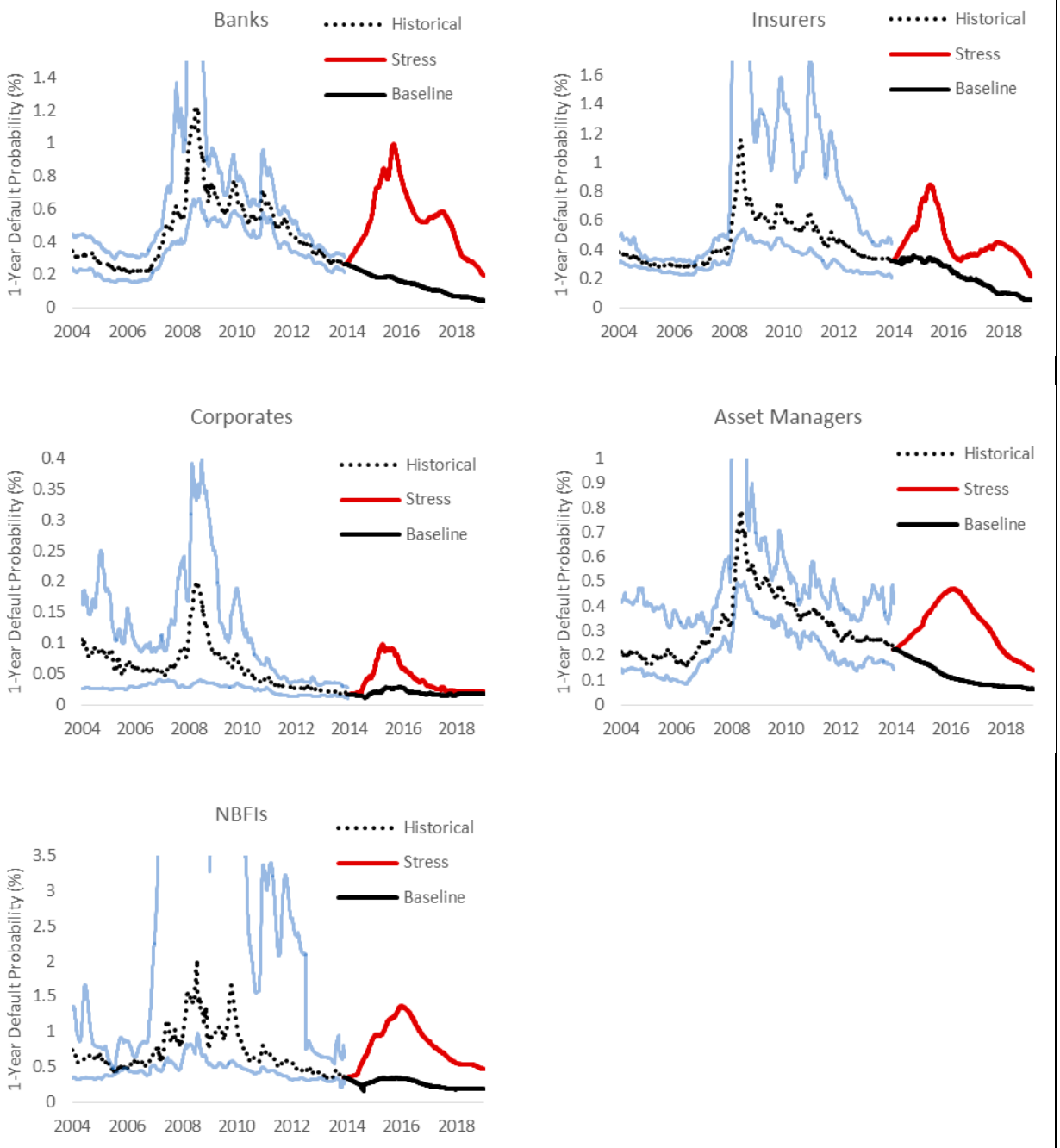
Source: IMF staff calculations

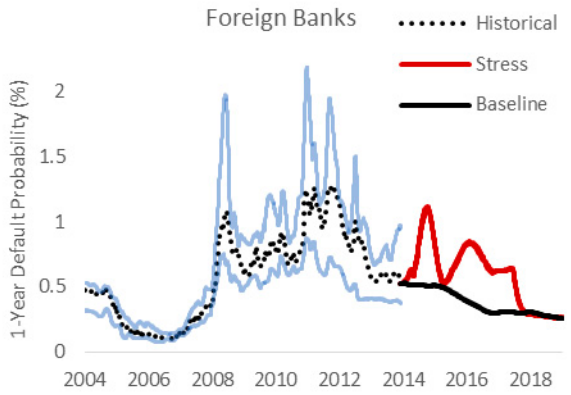
Appendix Figure 8. Overall U.S. Financial System Model: Non-Parametric Term Plots

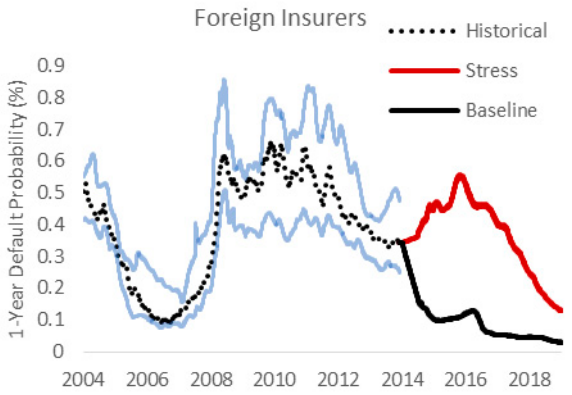


Soure: IMF staff calculations
Note: red lines denote the fit of a GAMLSS non-parametric additive term for the response variable (median 1-year ahead U.S. financial system default probabilites) against a given explainatory variable.

Appendix Figure 9. Sector Default Probability Forecasts



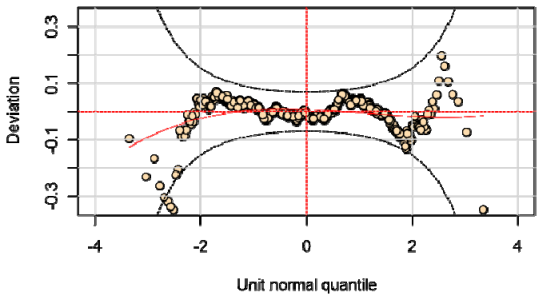




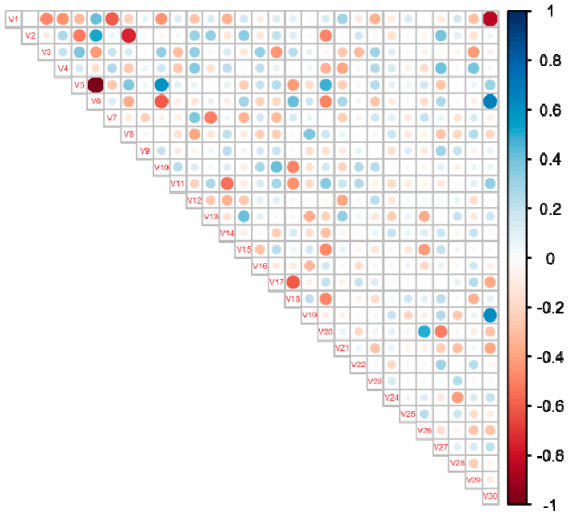
Source: IMF staff calculations.

Note: Blue lines indicate 25th and 75th percentile values of the distribution of historical estimates of U.S. institution 1-year ahead default probabilities. The dashed black line denotes the median value of the distribution of historical estimates of U.S. institution 1-year ahead default probabilities. The solid red and black lines denote median 1-year ahead default probabilities projected by the CCA stress tests under the stress and baseline scenarios, respectively. To better show projection details, the y-axis has been truncated for domestic banks, insurers, asset managers, and NBFIs. The blue lines denoting the 75th percentile reached maximum values of 4 %, 6.5 %, 2 %, and 16 %, respectively, for these four sectors in 2008-09. Only projections for the overall U.S. financial system model (Figure 18) explicitly take into account changes in the estimated default probabilities of other sectors. Individual sector projections were generated exclusively using macroeconomic and connectivity factors.

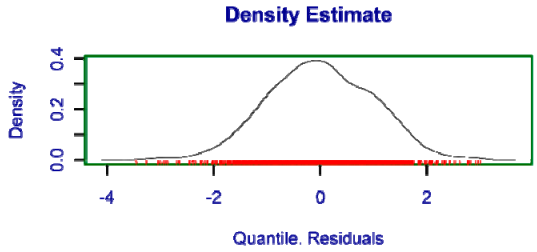
Appendix Figure 10. Additional Diagnostics for the Overall U.S. Financial System Model



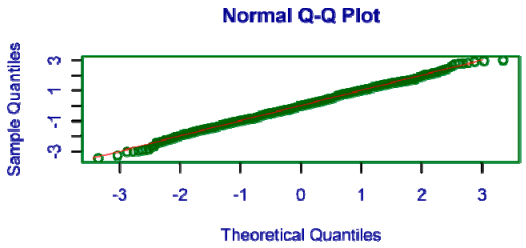
Worms plot (above) of the model's normalized quantile residuals suggests that the first two moments of the response distribution have been satisfactorily modeled. Curved dotted lines denote 95% CIs. The fitted central red line is fairly straight which is supportive of good model fit.



A correlation matrix of model predictors (above) shows that there is low correlation among the model's predicator variables and that the modeling assumption of uncorrelated predictors has not been grossly violated. (This low correlation is a benefit of including orthogonalized additive terms in the model.)



Model normalized quantile residuals closely follow a standard normal distribution which is a sign that the choice of distribution used to model the response variable was appropriate



Quantile-Quantile plot (above) shows that the model's normalized quantile residuals closely follow a standard normal distribution. This is another sign that the choice of distribution used to model the response variable was appropriate.

Source: IMF staff calculations

Appendix Table 6. Significance of GAMLSS Sector Model Spillover Effects

Distribution Type	Beta	Gamma	Inverse Gamma	Inverse Gamma	Generalized Inverse Gaussian	Generalised Gamma Lopatatsidis Green	Beta
Recipient Sector (right)	Banks	Insurers	Corporates	Asset Managers	NBFIs	Foreign Banks	Foreign Insurers
Overall U.S. Financial System						***	
Banks		***		***	**		
Insurers	***			**	***		***
Corporates							
Asset Managers	***	**			**		**
NBFIs	**		***				
Foreign Banks	*						***
Foreign Insurers		**				***	
Generalized R-squared	0.9731212	0.9886623	0.9840041	0.9640468	0.9128003	0.9841397	0.9904947

Significance codes: 0 *, 0.001**, 0.01*, 0.05'', 0.1'''**

Source: IMF staff calculations.
Note: Cells in the array above signify the statistical significance of the positive credit risk shocks illustrated in Figure 22. "Distribution type" refers to the assumed distribution of the response variable for each model (i.e., median 1-year ahead sector default probabilities). In the case of the overall U.S. financial system model only the effect of foreign sectors was considered. Unlike sector-specific models, response variable values for the overall model were drawn from a pool of domestic sector observations. This may prevent a proper comparison of shocks between the overall U.S. system and other domestic sectors.

Appendix Table 7. Financial Account Net Exposures: Sector and Instrument Definitions	
Sector/Instrument Name	**Component Financial Account Categories**
Households	Households and Nonprofit Organizations
Corporates	Non-Financial Business
Government	General Government; Monetary Authority Domestic Financial
GSEs	Government Sponsored Enterprises; Agency- and GSE-Backed Mortgage Pools
Banks	Private Depository Institutions
Insurers	Property-Causality Insurance Companies; Life Insurance Companies;
Pensions	Private and Public Pension Funds
Asset Managers	Money Market Mutual Funds; Mutual Funds; Closed End and Exchange Traded Funds; Real Estate Investment Trusts
NBFIs	Issuers of Asset-Backed Securities; Finance Companies; Security Brokers and Dealers; Holding Companies; Funding Corporations
Rest of World	Rest of World
Money Market	Net Interbank Transactions; Checkable Deposits and Currency; Time and Savings Deposits; Federal Funds and Security Repurchase Agreements; Open Market Paper
Fund Shares	Money Market Mutual Fund Shares; Mutual Fund Shares
Treasury Securities	Treasury Securities
Other Government Securities	Treasury Securities; Agency- and GSE-Backed Securities; Municipal Securities and Loans
Corporate Bonds	Corporate and Foreign Bonds
Corporate Equities	Corporate Equities
Deposits, Loans, Mortgages and Interbank Transactions	U.S. Deposits in Foreign Countries; Other Loans and Advances; Total Mortgages; Consumer Credit; Security Credit; Depository Institution Loans Not Elsewhere Classified; Net Interbank Transactions
Other Instruments	Special Drawing Rights (SDRs) Certificates and Treasury Currency; Trade Credit; Life Insurance Reserves; Pension Entitlements; Taxes Payable by Businesses; Proprietors' Equity in Noncorporate Business; Direct Investment; Total Miscellaneous Financial Claims
CDS	*BIS official statistics on credit-default swap notional amounts outstanding as of 2014Q2, adjusted for double-counting
Source: FRB's Financial Accounts of the United States; Haver; BIS; IMF staff estimates.	